SCHOOL SCIENCE
AND
MATHEMATICS

A Journal for Science and Mathematics Teachers in Secondary Schools

---

Founded by C. E. Linebarger

CHAS. H. SMITH, Editor
Hyde Park High School, Chicago

CHAS. M. TURTON, Business Manager
South Chicago High School, Chicago

DEPARTMENTAL EDITORS

BOTANY—O. W. CALDWELL
State Normal School, Charleston, Ill.

CHEMISTRY—A. L. SMITH
Englewood High School, Chicago

EARTH SCIENCE—C. E. PEET
Lewis Institute, Chicago

MATHEMATICS and ASTRONOMY—G. W. MYERS
University of Chicago

METROLOGY—R. P. WILLIAMS
Cambridge, Mass.

PHYSICS—W. E. TOWER
Englewood High School, Chicago

ZOOLOGY—FRANK SMITH, University of Illinois

VOLUME V. 1905

SCHOOL SCIENCE AND MATHEMATICS
440 Kenwood Terrace, Chicago

School Science and Mathematics

Vol. V JANUARY, 1905 No. 1

SALUTATORY.

In assuming the responsibility of preparing, each month, School Science and Mathematics for its body of progressive readers, the editors realize that their success will come only through the united efforts of those teachers who are anxious and willing to place instruction in Science and Mathematics on a higher plane.

The former editor has transfered to us a Journal of high character which has had an assured success from its very beginning. It will be our endeavor to maintain this high standard, making it a necessary trade Journal on every Science and Mathematics teacher's desk.

A demand for such a Journal has long been felt. Being the only Magazine of its kind published in the English language its mission is necessarily great. It is through its columns that new ideas and methods of Scientific and Mathematical instruction can and will be given to the world. Only the strongest and most progressive educators will be contributors to its pages, and in this manner the young and inexperienced teacher will be given the help of those who are advancing in ways and means of modern instruction. Our readers are asked to inform us of any paper or articles and description of apparatus, with drawing, that

will be worthy of publication. It is also intended to make the columns of this Journal the medium through which Science and Mathematics teachers may communicate with each other, in fact, act as a clearing house for all that is advanced and good in Scientific and Mathematical instruction.

It is proposed to make the Journal a medium of exchange between the different Scientific and Mathematical societies existing in many states. In this manner each association will be kept in touch with the others. It will advocate the bringing together of these different bodies into one strong and influential association which may well be called the National Association of Science and Mathematics teachers.

This is the only Journal maintaining a department devoted to the Science of Meteorology.

Problems relating to secondary instruction are vitally connected with those of the college; this journal will, therefore, throw open its pages to college men for the purpose of discussing those questions which are of common interest.

It will endeavor in every way to bring about a closer union between college and secondary teachers, to further the usefulness of all Science and Mathematics associations and to advocate and promote all those methods of Scientific and Mathematical instruction which will work for the greatest good to all concerned.

The former Editor, Mr. C. E. Linebarger, owing to pressure of other business, has been compelled to sever his active connections with the magazine. He will, however, act in an advisory capacity.

THE INTRODUCTION OF METEOROLOGY INTO THE COURSES OF INSTRUCTION IN MATHEMATICS AND PHYSICS.

By Cleveland Abbe, U. S. Weather Bureau, Washington, D. C.*

The study of Meteorology has acquired a new and vivid interest since the establishment of fairly successful official weather forecasts in this country and Europe. The civilized world now knows that the weather and the climate, the winds and storms are controlled by rigorous laws of nature, we may not understand them all as yet, but they are in control of the universe and we are to discover them and utilize them for the benefit of mankind. We have not yet found any limit to the attainments of the human intellect and what the mind can do in the way of thinking the hand will find some means to attain in the way of doing. We must think out our work before we can do it.

The ultimate object of all our systems of education, elementary, collegiate and post-graduate is to train the mind to think and then train the hand to do. In old times the schools crammed the brain with the results of work already done, memorizing a multitude of facts; but now, while not neglecting the memory, we seek to develop the reasoning faculties, or the reasoning habit of thought, and then to perfect our methods of doing. Our schools pay much attention to mathematics, mechanics, chemistry and science in general, because these have an important practical bearing on our lives. In this movement toward the professional side of education meteorology has not been neglected altogether. I have been greatly pleased to see the enthusiastic reception accorded it in every part of the Union and its growing popularity in both graded and high schools. I suppose that we owe this specifically to the general success of the weather bureau, but more particularly to Prof. Wm. M. Davis, who established a school of meteorology about 1878 as a division of the school of geology at Harvard University. His students and text books, his Elementary

* An address delivered before Physics and Mathematics Sections of Central Association of Science and Mathematics Teachers, Nov. 26, 1904.

Meteorology and the Climatology of his successor, Prof R. DeC. Ward and their methods of teaching have awakened teachers and professors alike to new possibilities. Other schools and other text books have come into existence. The elements of the subject are now so well provided for that I do not need to say more about this; but I do feel the need of further advances.

I regard Meteorology not so much as a matter of observation and generalization as matter of deductive reasoning. Our studies have approached the limit of what we are likely to discover by inductive processes. We stand where astronomy stood in the days of Laplace. We have had our Galileo and Newton, but we still need other leaders and you will all agree with me that these must be trained in the schools. They must get their first lessons from you. Twenty or thirty years hence our future masters in meteorology will tell how their feet were turned in the right direction by the teachers of to-day.

In every school I find several boys or girls that have taken a deep interest in the weather and its relations to our lives. They are often asking questions that bear upon it. They appear to observe and understand it better than others. These are they whom I would have you secure for the possible service of the weather bureau. There are others that often appear dull, but are not really so; their previous education has perhaps been imperfect, someone has confused their minds with erroneous ideas from which they cannot easily rid themselves. There are others who have not yet awakened to a full interest in intellectual work. In general the school will be benefited by taking up exact and experimental work as compared with inexact, indefinite, texts or phrases. We benefit a child more than we realize when we give him exercises in exactness. Why do we make him calculate interest to the last cent. Why practice the piano or singing until he can do it properly. Why draw or paint correctly? Why speak English precisely? Is it not our conviction that what is worth doing at all is worth doing well? It is only the things that are well done that tell. Even in morals it is the bad thought that is the first step towards a bad act. So I wish to enforce the idea of teaching meteorology accurately and to do this we must use

accurate expressions and experiments, accurate figures and drawings and correct mathematics. On the other hand we enliven all mathematical and physical courses of instruction if we introduce into them applications to familiar subjects. The dullest student becomes alive as soon as he perceives that his distasteful mathematical tasks will help him to understand some subject that really interests him. There is no one, not even a child, that has not some favorite subject of thought, some one unanswered query, lurking in his brain. Find out what that is and you have found the keynote to which all his education may be made harmonious.

I know that the schools and colleges find so many subjects to teach and the hours of work are so taken up at school and at home, that you will say, it is out of the question to introduce another new study. However, I do not venture such a presumption, but would suggest a simple and practical scheme. The idea is simple.

When you are teaching mathematics or physics and seeking for examples illustrative of the application of these subjects, give especial attention to Meteorology and take your examples from the phenomena of the atmosphere. You may not at first find many cases, certainly there are very few in the books. You may have to draw upon your own reading and knowledge, or on the notes that you will find in the Monthly Weather Review. But with a little ingenuity you will soon accumulate quite a goodly number of problems that will afford your students abundant food for thought.

I find that many take up mathematical physics as one of the sources leading to the various engineering professions, because the latter offer them a prospect of a good business for life, but occasionally one of these finds himself interested in the scientific or research aspect of the various problems as much or even more than in the engineering aspect. He will probably combine research with his business, if indeed he does not altogether relinquish the latter for the former, provided a favorable opportunity offers. Now of such are the men from among whom the ranks of the future army of American scientists will largely be recruited and if you find any such, you will do well to help them develop

their tastes for meteorology. They have studied mechanics, thermodynamics, steam-engineering, electrical engineering, hydraulic engineering; they are graduates of our schools of engineering, they have also the very best foundation for research in meteorology and their tastes incline in that direction. One cannot expect to make any great advance in this science without having both a broad foundation, an enquiring mind and great intellectual energy and perseverance. If the colleges and universities are not yet ready to give meteorology an independent place, a professorship, an observatory, a laboratory, as they do for astronomy, chemistry, geology and many other branches of knowledge, then the best temporary arrangement that we can make is to introduce it freely among the problems illustrative of the general courses in the fundamental, mathematical and physical studies of all exact science.

But you will ask for some definite examples and I have time to mention a few.

Among the simpler applications of trigonometry are the various efforts made to determine the altitudes and motion of the clouds. The simplest method consists in determining the actual motion of a cloud by observing the perfectly parallel and equal movement of its shadow on the ground. One may stand upon an eminence and survey the landscape and with the help of a good map and the seconds hand of a watch or a simple seconds pendulum, may determine the direction of motion and the linear velocity of as many shadows as he wishes. If now at the same time he looks directly upward and observes the apparent angular velocity of a cloud as it passes the zenith, he will find that he knows the base and one angle of a right angled triangle, of which the other side is the cloud-altitude, which of course can then be computed by trigonometrical tables or still better by geometrical constructions. Trigonometry and geometry, arithmetic and algebra should all be kept at the finger tips ready for use by young students of science. Oftentimes a young man will stand in front of a theodolite or some other complex apparatus and feel that it is too much for him; some have their heads full of mathematics, but do not know what to do with it. The expert is the man who

both has the knowledge and can do something with it. Our education should insist on the practical and quick utilization of every scrap of knowledge that we are the fortunate possessors of.

Another ingenious application of geometry to the altitude of clouds is known as Feussner's method. An observer stands at O and sees a shadow at K at a spot that he can identify on a detailed map of his surroundings. He recognizes that this shadow is that of a cloud at C and he therefore observes the apparent angular altitude of that cloud, which is the angle COK in the triangle. Now the angle CKO is the same as the apparent angular altitude of the sun, since a line drawn from O to the Sun would be parallel to the line drawn from K through C to the Sun. If, therefore, the observer measures the angle by which the sun is above the horizon or SOH he then knows the base OK and the two angles at O and K and may compute or construct the vertical height of C above the horizon. There are several refinements to be thought of. K may not be on the same level with O; the cloud may have moved before he can observe its altitude and the Sun's altitude after having identified the shadow K as belonging to the Cloud C. These refinements offer slight difficulties that may be overcome; if one has a correct watch he may simply observe the time when the shadow was at the point K and from that compute at his leisure the altitude of the Sun.

One of the oldest methods of determining the altitude of a cloud is known as Bernoulli's; the observer at O sees the Cloud at C just as the last ray of the Sun illuminates it. This last ray must have grazed the surface of the earth at some point W below the Western horizon. By observing the time, we know at once the angle between the radii drawn to the earth's center from O and from W. This gives us the means of computing the distance from W to our vertical. But we also observe the apparent angular altitude of the cloud or the angle between O.C. and the vertical. We have now all the data needed to solve the problem. We have in fact three triangles to solve in succession. The problem becomes more complicated if we endeavor to allow for the refraction of the ray of light from W to C. I will not give the latter complex formula now, but may say that I hope to publish a long

series of these problems in a little handbook for the use of students and teachers and I think that you will not find them too difficult for most of your students. In fact text books on trigonometry which give us many interesting problems suggested by the work of surveyors, navigators and geodesists, seem to have quite forgotten that the clouds offer us still more fascinating problems.

Some years ago the various weather bureaus of the world agreed upon a year of steady work on the altitudes of clouds. Some observers adopted the strictly trigonometric method of altitudes and azimuths. If a theodolite is placed at A and another one at B, the observers endeavor to sight simultaneously on a cloud at C. If they sighted on the same point at the same time and observed the altitudes and azimuths correctly, then it would seem certain that with AB as the base line they should be able to compute the linear distance of the cloud C and its altitude. But unfortunately a cloud has considerable size and there is never an absolute certainty that A and B observe the same point. Accordingly there arises a very interesting problem as to what points they have observed. Oftentimes calculations showed that the two lines of sight did not and could not intersect, so that the shortest distance between the two lines would seem to be the proper place for the cloud. You will find all the details of this problem in chance or the theory of errors, as it is called, in a report by Ekholm and Hagstrom.

During that same year other observers used what is called the photogrammeter or the nephograph, which is simply a photographic camera mounted with altitude and azimuths circles. Photographs are taken of the same clouds simultaneously and from them we may proceed in several methods, either (1) we may measure from the photographic plate and angular distances of various points in the clouds and determine the distance and dimensoins of the whole cloud, or (2) we may proceed graphically, set the photographs up in a frame, reproducing as nearly as possible the original locations of the two cameras and then, using threads as lines of sight, carve out in the air of the room a small model of the cloud itself. This latter process was, I believe,

first carried out in England under the supervision of Prof. G. G. Stokes, the eminent mathematician, who was at that time a member of the Meteorological Council at London. In fact, that Council has often included some of England's most famous men and we are indebted to them for a number of important methods in meteorology.

But perhaps the most fascinating as well as the simplest methods of studying the clouds is by means of the nephoscope. This is a very simple instrument, merely a circular mirror held horizontally; you look into it and see the cloud by reflection, which saves the trouble of twisting the neck in an uncomfortable position. The mirror has a graduated circle corresponding to the azimuth circle; its center is marked by a dot or cross line and there are a few concentric circles drawn around that. At one side of the mirror is a light vertical rod holding a little knob, which may be raised or lowered and turned around to any azimuth so that when one observes a cloud reflected at the center of the mirror, he may so adjust the knob as to bring its image also at the center. But the cloud moves away and the observer must then move his eye so as to keep the knob covering the cloud until the knob and cloud disappear together at the edge of the mirror or cross some one of the concentric circles. In this process the knob is the center or intersection of two lines of sight, one from the cloud to the knob in its first position and again from the cloud to the knob in its second position. The horizontal path described by the intersections of these lines with the face of the mirror, is a miniature of the horizontal path described by the cloud in the time required by the images to pass from the center to the rim. We obtain thus the direction of motion of the cloud and a horizontal line that may be converted into the angular zenithal velocity. The prettiest application of this instrument and perhaps the most elegant of all methods of determining the height and velocity of the cloud, I have called the kinematic method. The idea is this. If we are in a boat or on a train, our motion is combined with the motion of the cloud. We seem to attribute our motion to the cloud and the observed line is a resultant movement, that you easily obtain by compounding movements or forces by

the method of parallelogram of forces. If we move from A to B in the boat with our nephoscope it is as though the clouds move from B′ to A′ in the parallel but in opposite direction, but if the cloud is actually moving from B′ towards X, then the result that we observe is the line B′ X′ as seen from the boat. This apparent angular motion we are to observe first when the boat is going from A to B and again when the boat is going in some other direction, such as B to C, or even when the boat is stationary, or when the boat directly reverses its movement which we can most easily accomplish by carrying our nephoscope on a trolley or in a row boat on a canal. Now these two observations, together with the known velocities of the boat, give us four known terms in a pair of trigonometric equations from which by elimination we determine the altitude and the actual velocity of the cloud. The most difficult point is to determine the velocity of the boat and the method is therefore best adapted to give accurate results when the nephoscope is being carried by a steady steamer or by a car that is pulled by a cable, going at a perfectly uniform rate of speed in different directions, as for instance through the streets of the city.

In the purely mathematical department, I happen to think just now of the so-called Poisson's equation relating to the behavior of pure dry air, when undergoing adiabatic changes. This is given in some works on analytical mechanics and is mentioned in the elementary works on physics. But the good student will appreciate it better if you will give him the demonstration based on fundamental principles which may be made almost purely mathematical.

When the same ideas are applied to the expansion and contraction of moist air with its changes from vapor into cloud and snow, we come upon a more complex problem in physics; but even this is so largely a question of pure mathematics that it may be included under that category and I hope that you will make your scholars familiar with the elegant graphic methods introduced by Hertz whose paper is fully translated in my "Mechanics of the earth's atmosphere" and has been still more beautifully treated by Neuhoff in a German paper in 1901 but not yet

translated. Elaborate mathematical tables are given by Professor Bigelow in his "Report on International Cloud Observations."

The elementary text books on physics often mention the theory of the wet bulb thermometer and its use in determining the moisture of the atmosphere but they rarely give any satisfactory explanation of the process by which physicists have deduced the relation between the temperature of the wet bulb and the moisture in the air, that is to say, the rate of evaporation; the process is not so difficult but what any one who has studied a little of the law of diffusion can understand it and for brevity's sake I must refer you again to my "Meteorological apparatus and methods."

Mathematics and physics go hand in hand, so closely that we dare not think of separating them. If one experiments he keeps the mathematical laws in mind; if he studies the subject mathematically he keeps the physical laws in mind. A problem in one is also a problem in the other, both are rigorous and develop the reasoning powers—but sometimes it is easier to handle the experimental than the analytical method.

In the Monthly Weather Review for 1897 will be found a splendid memoir on the Equations of Hydrodynamics arranged for the study of the general circulation of the atmosphere. This and the corresponding solution of the complex differential equations gives the mathematician more than he can handle at present, but the suggestive paper by MacMahon, read at the recent International Scientific Congress on the n-fold Riemann surface, opens up great hopes for the future.

Meanwhile we must mingle experiment and theory; each must guide the other. The physicist may, in his laboratory, carry out some of the following experiments and at a glance perceive the resulting atmospheric motions, or, the solution of the differential equations under any given special conditions that the analyst would find it difficult to attain—but can easily confirm when once the result is known.

We may experiment on small local motions before proceeding to the larger ones.

In a large room or in a case with double glass walls, so that

the inside temperature may be controlled, let a shallow stream of cool air flow along the bottom. By giving this a slight but adjustable slope the rate of flow may be regulated; by altering the bottom we may pass from water or smooth sand to wavy, rolling prairie or ranges of hills and mountains. We may imitate every variety of ordinary atmospheric motion.

By utilizing a layer of CO_2 for the bottom we may even study the flow of upper air currents over lower ones.

We make all these movements visible by introducing a little smoke, but especially by applying the so-called "Schleier" method of Foucault, as perfected by Mach and Dubois, which enables us to photograph the feeblest differences of density whether due to pressure or temperature or moisture.

Among other problems in aerodynamics should be mentioned that more elementary one, the hypsometric formula of Laplace. Our students and the surveyors and mountaineers use this with aneroids for determining altitudes, without understanding its derivation or the sources of mistakes in applying it—especially the uncertainty of our knowledge of the temperatures of the air. Now the formulas may be deduced analytically by integration of the simple differential formula or by algebraic or geometric or arithmetical or graphic method and all should be combined as an illustration of the unity of logic in whatever form presented. Science is but logic applied to material nature.

I will merely mention some other problems that appeal to us from both analytical and experimental points of view.

The total resistance and the pressure and motions of the air all around a resisting plate sphere or other obstacle.

The action of the wind in producing "suction" at the top of an open pipe or chimney.

Among problems that may be handled first by pure mathematics and then by experiment and observation are the determination of the calibration correction of a thermometer, the protruding stem correction and the Poggendorff Correction.

These belong to elementary physics but will give your students a chance to apply their mathematics to physical problems.

A complex trigonometrical problem involving a slight knowledge of astronomy is the determination of the duration and intensity of sunshine or the total amount of heat received by a unit horizontal surface for any moment of the day and the year. The calculation is to be made for the outside of the atmosphere, because, if we attempt to take allowance for the absorption by the atmosphere the problem becomes too complex for our present purposes. The simpler problem may be treated geometrically and graphically and is essentially a matter of familiarity with "the use of the globes" as it was called one hundred years ago.

Globes and charts are vital matters in meteorology and are elegant classics in geometry. Chartography and projections and the globes themselves are too much neglected—pushed aside by the crush of new demands for instruction in every other branch of knowledge, but those are absolutely fundamental to astronomy and meteorology, terrestrial physics and all geographic relations, and I hope to see them properly appreciated in the schools of pure mathematics and terrestrial physics. The properties and methods of construction of various equal surface projections ought to be as familiar to a student as those of the ordinary stereographic projection. The problems of chartography are beautiful for the drafting room but more vivid and better adapted to the comprehension of many persons if worked out on the globe itself—and one does not need an expensive globe—even a home made globe or rubber ball can be very useful.

The globes and conic section *in solido* should be handled by your students at some early stage in their education.

But finally to return to our aerodynamics. Nothing can be more attractive to a student than the formation of a waterspout by Weyher's method and the study of the wind velocity and pressure, the barometric pressure, the temperature and the dimensions of the cloud column.

We simply set a horizontal disk at the top of a room or closed case into rapid rotation. Soon the air beneath is dragged into rotation down to the very floor. Below it we place a dish of water and the vapor from it is drawn up into the inner revolving

vortex while at the same time thrown out; eventually it descends and ascends in regular circulation. As the disk and air increase their rotary speed, the central vortex diminishes in barometric pressure while increasing in velocity and the moist air flowing into it cools by expansion, forming a central waterspout column or vortex. Here we begin to be stirred with a desire to measure. We insert a long Pitot tube and determine the wind pressure at many points and chart the pressure or velocity on ruled paper.

We insert a pair of small plane plates as in my method of barometric exposure (see Meteorological Apparatus and Methods), and determine and chart the pressure at many points, We send a thermometer or thermo-electric junction exploring the vortex and plat the temperature, or we use some form of hygrometer and determine the dewpoints. In fact we experimentally determine all the elements that enter into the structure of the waterspout and compare our observations with the theories that have been worked out by Ferrel and Bigelow.

I have said enough for the present. I hope to elaborate this effort to help the mathematician and physicist to find a new field of problems for their students. Thus they will help us to develop the talents of future Meteorologists.

These are but special illustrations of the general law that thinking, seeing and doing must go together. We learn by doing as much as by reasoning—each helps the other. Every theory or hypothesis or suggestion should be reduced to exact formula, exact experiment, exact measurement. Precision is the vital essence of all valuable knowledge.

I hope to live and see special schools of Meteorology, special laboratories and mathematical seminaries devoted to this as to every other profession, but for the present at least I urge that you illustrate the value of and enliven the interest in your mathematical and physical courses by frequently quoting or proposing problems drawn from Meteorology.

SOME ASPECTS OF TECHNICAL EDUCATION WITH ESPECIAL REFERENCE TO THE TEACHING OF PHYSICS.

By Howard M. Raymond, Dean Armour Institute of Technology, Chicago.*

Among the gigantic strides of human progress of the nineteenth century and up to the present time, it is safe to say that the greatest has been along scientific lines. In the dawn of the twentieth century we find ourselves in the midst of the greatest industrial activity and development that the world has ever seen. Science and invention have placed vast resources at our command. The material wealth of every country is being developed; railroads are built; mines are opened; towns are established; commerce is encouraged. Every effort is put forth to make living less costly and more comfortable.

Until the last few years the province of American manufacturers was to supply the domestic wants of this country. When the output exceeded that demand, collapse came from over production. Now our markets are broadening; our opportunities are increasing; our resources are being developed beyond our requirements, and increasing population demands increased occupation and production. Trade and territorial relations have been established in the Orient, and we are destined to secure our fair proportion of the commerce of that thickly populated and now rapidly opening section of the globe.

Under these pressing conditions of expanding industries and new markets throughout the world, an aggressive competition must necessarily follow. The skilled artisans and the accomplished merchants of the Old World will not willingly surrender their trade or prestige. We may accept complacently the popular estimate of our superiority in natural resource and inventiveness, but we are confessedly not their equals in trained skill and tried experience in that field which they have held so long.

It is not alone, however, in meeting competition in foreign markets that a successful field for educated labor and industrial

* An address delivered before the Physics Section of Central Association of Science and Mathematics Teachers, Nov. 25, 1904.

training is offered. The marvelous strides made in our own country in manufacturing of all kinds, in electrical, mechanical, civil, mining, chemical and fire protection engineering reveal an unprecedented demand for technically trained engineers. We are, therefore, able to comprehend some of the broad and diversified fields of usefulness and profit which are open to young men who will properly fit themselves for the commercial and industrial arts. It is to supply this broad material sphere of activities with capable men that so many technical schools have recently been established throughout the country. There has been nothing in our national history more significant or more distinctive than the origin, growth and the amazing development of these institutions of learning.

The purpose of this paper is not to discuss, to any extent, the ideal course of study for students to pursue in such institutions, but rather to consider more closely certain phases of their preparation which is to fit them for an engineering education.

An address given before the Physics section of the Central Association of Science and Mathematic Teachers, Nov. 25, 1904.
learning.

In the engineering courses of today we try to combine, in four years, professional training with research and culture. This, however, is difficult to do, for while the professional work is reasonably complete, culture is at a minimum and research crowded to the wall. The subject of law requires three solid years for professional training alone. Three or four culture years go with this and are surely none too many. The same requirement should eventually be made for engineering. A college of engineering cannot turn out a finished engineer in four years, since there are many things besides engineering which go to the making of a real engineer. Of all professional men, he should be an individual of broad, general culture, because of the very nature of his profession and of the constantly increasing scope of his activities in all departments of life. A certain amount of culture must be given before the student enters the technical school, and here is the weak point of our present day training. Students come to the College of Engineering before they

know how to study, and much of the time is spent in acquiring that systematic habit of work which they should have brought with them. While we cannot prepare a student within four years to become an engineer and also a man of broad general culture, we can show him in that time the line of his professional advancement and can see him well started in that direction before he receives his degree. We can give, in the college course, something of the methods and results of advanced research. In any subject, the advanced work has a higher culture value than elementary work.

The one subject in which we find the entering students to Armour Institute of Technology woefully deficient is English. The teacher, however, may not be wholly to blame in this matter, for it seems to be the prevalent feeling among students about to take up an engineering course that the study of English is of little importance. Teachers of High School English inform me that it requires more than ordinary effort to interest the pupils of their classes who are contemplating engineering courses. This is a sad state of affairs, and if these students could have presented to them the opinions of our great engineers on this subject, I am sure it would have a salutary effect. The chief engineer of one of our large electrical concerns recently told me of a young man employed in one of the main departments whose failure to be promoted to the highest position in his department was due to his lack of knowledge of the English language. That too much stress cannot be laid upon this all important, but sadly neglected subject, is the opinion of all successful engineers today.

Prof. John Perry, whose opinions always claim our closest attention and for which we have the profoundest respect, expresses himself as follows: "Well equipped schools of applied science are getting to be numerous, but I am sorry to say that only a few of the men who leave them every year are really likely to become good engineers. The most important reason for this is that the students who enter them usually come from the public schools; they cannot write English; they know nothing of English subjects; they do not care to read anything except the sporting news

in the daily papers; they cannot compute; they know nothing of natural science; in fact, they are quite deficient in that kind of general education which every man ought to have."

While this state of affairs in England is much to be deplored, let us congratulate ourselves that such a criticism is altogether too severe to be applied to our own system of preparatory teaching.

Realizing the importance of the study of English to the engineering student, the Armour Institute of Technology has recently inaugurated the system of requiring laboratory notebooks and bulletins to be presented to the English department for criticism and correction. At least once a term, the head of each of the engineering departments submits to the Professor of English, for his criticism, a set of papers taken from the regular work of that department in the Sophomore, Junior and Senior years. These papers are corrected and returned to the student, and the Professor of English has the authority to cause any student deficient in English to report him for special work in that subject. All graduating theses are submitted to the Department of English for criticism before they are presented to the Executive Committee of the Faculty for final judgment.

The subject, however, of the most importance to the student contemplating a course in engineering is Physics. When we remember that engineering, in all of its branches, is only the application of the principles of Physics, we can realize how necessary it is for a thorough and practical foundation in that subject. It has been one of my duties for the past five years to examine the students in Physics and to pass upon their laboratory notebooks for admission to the College of Engineering. I have, in that time, examined the work of approximately a thousand students from high schools and academies in nearly every state in the Union. While the preparation, in general, has been very satisfactory, I have made a few observations of points upon which more emphasis should, perhaps, be laid by high school teachers in preparing students for the study of engineering.

In the first place, I find many of our Professors of Engineering complaining that too little stress is laid upon the subject of

Mechanics. While it is true, that in the interim between the completion of the study of Physics in the high school and the taking up of the College Physics, the student forgets many of the principles he has learned, there are certain fundamentals upon which he should be so thoroughly drilled that he will never forget them. Especially in Dynamics does the teacher of Engineering Physics find his pupils either poorly prepared or their memories exceedingly faulty. Much valuable time would be saved the instructor if his pupils could bring with them a clear idea and conception of the Units of Force, Units of Work, and the subjects of Acceleration, Rate of Change of Momentum, Impact and Energy. In connection with the above, I will add the subject of Angular Velocity, which is of great importance to the mechanical engineer, and the fundamental ideas of which should be given in the Preparatory Physics.

In the second place, if there is one general topic more than another in the study of Physics which should receive extraordinary attention and upon which the student should receive special drill, it is that of Units. In the general term I include, of course, Electro-magnetic Units, Units of Heat, Units of Force and Units of Work. The engineering student makes constant use of these from the beginning of his Sophomore year until he graduates. It seems unjust that the instructor in College Physics should be compelled to curtail the time for his regular work in order to explain what the student should have brought with him from the high school, yet this is only too true, and on behalf of our engineering instructors I suggest that more drill and more problems be given in dealing especially with the Units of Force and the Units of Work.

Furthermore, a subject upon which emphasis should be laid and which some textbooks fail to mention in any way is that all-important engineering principle of Moments of Forces. Other subjects of especial moment to the engineer are Composition and Resolution of Forces, Friction, Elasticity, Efficiency and Mechanical Advantage of Machines, Boyle's Law, Fluid Pressure and Heat Energy. An abundant use of simple practical problems is thoroughly recommended for the above subjects. It is only by the

varied application of the principles of Physics to practical problems that the student can acquire that firm grasp of ideas which comes from constant use.

Two other subjects of vital importance, and of which the high school student usually has little or no knowledge, are Simple Harmonic Motion and Moment of Inertia. While it is impossible to treat these subjects from a mathematical point of view, the physical conception should at least be given.

Another very important desideratum is a more intimate connection between the studies of Mathematics and Physics. While students are able to use and manipulate the physical formulae in the majority of cases, they fail to give to them the proper physical interpretation. However, as another paper has been prepared on this subject, I shall not enter into a detailed consideration of the question.

It is true that many high school teachers seems to undervalue the importance of the study of Mechanics. Nevertheless, it is a fact that it is the backbone of an engineer's college training. It is only with a thorough grounding in the fundamentals of this subject that the student can take up the studies of his college course without grim discouragement and possibly failure staring him in the face. To the ordinary pupil, this branch of Physics is usually uninteresting and difficult, and the teacher should exert his greatest effort to conduct his classes in a way that will interest and, at the same time, impress upon them its unusual importance. The instructor should also remember that it is upon his skill and ability in devising practical experiments in the laboratory that the students' thorough grasp of the principles finally depends.

The immediate aim of instruction in Physics should be to give the power and the habit of using physical knowledge. The enthusiastic and observant teacher will encourage his pupils to see and think about physical phenomena and physical devices which are outside of the class-room. If the pupils are sufficiently interested to bring to the teacher their observations from a visit to a machine shop, factory, power station, electric light plant, steel works, car shops, or even from their daily walk or ride to

school and recognize any of the principles they have learned, then the teacher may well feel satisfied.

In connection with the laboratory work in Physics, there is one feature, the growing tendency of which is gladly welcomed, and that is the plotting of curves and graphical methods in general. The importance of this practice cannot be overestimated in connection with technical work. The use of cross-section paper should be extended to every experiment that will permit of its use, and care should be taken that the pupil thoroughly understands its meaning. I remember, some years ago, one of the experiments I gave, to illustrate the plotting of a curve, was that of the pendulum, where the string was lengthened a number of times and the time in seconds for the swing of each successive length was taken. These were plotted with the times as ordinates and the lengths as abscissae. It was not, however, until the times and square roots of the lengths were plotted, giving a straight line, that the students fully appreciated its meaning.

A feature of laboratory work, in which it seems there is room for improvement, is in arranging and devising experiments so that the student may not know the outcome beforehand. It is always the natural tendency for the student to turn either to his tables, or some other place of reference, and anticipate the result. It is surprising sometimes to know what remarkable and accurate results are obtained by students which, with the apparatus at their command, the instructor knows to be well nigh impossible, barring accident.

I have known students, with the aid of a string, a lead ball and an ordinary watch, to determine, after repeated trials, the value of gravity accurately to two decimal places, and by measuring the circumference and diameter of an ordinary wheel, to determine the value of II. to five decimal places. While the temptation on the part of the student to do this is great in many experiments, especially those in Mechanics, there are many occasions where it can be prevented.

Attention may be called here to the fact that the student too often fails to clearly recognize the connection between a definition, or statement of a law, and the result of an experiment. A

student, for example, who has taken two different masses connected by a string passing over a pulley and has determined the moving force, the mass moved and the acceleration, certainly is in a better way to clearly grasp the meaning of Newton's second law of motion than the student who accepts it as a mere convention. Again, let me suggest, in this connection, as thorough a drill on practical problems as time will allow. Not a few of the candidates for admission to our College of Engineering are able to give every definition and state every law and principle within the covers of the textbook, but are utterly at sea in knowing how to apply these principles they have memorized so well. It is gratifying to state, however, that there seems to be a general tendency throughout the country for instructors in Physics to be less spectacular and more practical in their teaching; to pay more attention to the great underlying laws of nature, rather than its beauties. So many students, upon completing the study of Physics, seem to feel like a laborer who has finished his task and sat down to rest. They heave a sigh when they find they have passed the subject and immediately proceed to forget it. The teacher who can instill into his pupils a *continual desire* to investigate and master the energies and forces of nature is as powerful an engineer as the builder of the greatest bridge or the mightiest man of war.

The young man of today should be impressed with the fact that this is a scientific age and that scientific methods enter into all branches of business and departments of industry. No matter what his plans for the future may be, let him understand that whatever vocation he may choose, his scientific training will contribute in no small way to his success in that particular department of activity. Let us, then, as sponsors for his early training, assist him in laying a strong, practical, scientific foundation, so that he may go forth to do battle with the world equipped with the weapons of modern warfare, and not "with the shield and sword of an ancient gladiator."

DOES THE WORK OF THE GRADES PREPARE FOR HIGH SCHOOL MATHEMATICS?*

BY MISS LIZZIE CRAWFORD
Nebraska State Normal School, Peru, Neb.

(Continued from p. 224 School Mathematics.)

Perhaps it would have been better for those who come through the grades if the teacher had used as a basis Dr. Dewey's idea of number work. He tells us that number is the product of the way in which the mind deals with objects in making a vague whole definite. He gives us to understand that there should be no simply looking at objects, but whatever objects are used should be used in a constructive way. He would have us learn that number ideas do not arise by hearing symbols or looking at objects, or even by the handling of objects unless the handling of the objects is for a definite purpose, the concrete representation of a thought that has been born within the child's mind. The need of the number to express more clearly the thought of the child should be the only excuse for bringing it into this particular recitation.

If we take this latter view, that the need of the number to express the thought of the child should be the basis of consideration, we have this grouping—child, thought and number. When the need for "four" to express some thought that the child has is the cause for learning "four," when the impulse toward "four" is from within, a growth of mind, a satisfying of some desire on the part of the child, we may hope for "four" to be retained. Learned thus it will not be a fleeting image, but a real possession. We will all agree with Miss Arnold when she tells us that the child comes slowly to the power to think, and we are often tempted to put the words into his mouth in order to hurry the desired results, but we hardly gain anything by our impatience. The child merely accepts our words. He does not think.

Is it not for the purpose of hurrying the process of thinking that we bring the objects before the child before we have created a need for those objects? Do we not usually begin with number combinations rather than number ideas? What is true of the

* Read before the Nebraska Teachers of Mathematics, December 30, 1903.

number concept is also true of the combining of numbers. We have been in too great haste to rush the forty-five facts of addition and other facts of the fundamental processes upon the child. We have not been willing to wait for the occasion to arise that necessitated a knowledge of the number facts. We have not considered the interests of the child sufficiently in planning the work for him, but have had in mind what was to be taught rather than the learner; hence, we have appealed many more times simply to the child's vision, to his seeing four objects, than we have to leading the child into paths that would make the number combination the expression of a thought. In other words, the very foundation of our work has been largely external, not the result of thought processes. The use of cubes according to Grube, the use of forms according to Speer, the pegs, corn, stick when simply placed in piles or arranged in rows, with nothing back of it except number arrangement, is purely external work. On the other hand, when the teacher has made the use of blocks, Grube or Speer pegs, corn, etc., the means of working out some number idea that has come to the child through his nature study, his reading a story, the morning talk or any one of the various interests touched during the day's work, we have the number combination coming as the result of thought.

"The more thought that surrounds the combination when it is first presented the less is drill necessary to make the number fact automatic." If the thought is at ebb tide and the form side uppermost when the combination comes to the child the more will drill be necessary for the fact to become his own. The child in getting the number from the external side needs ever the repetition of the objects before memory will retain the facts to be learned. There must be conscious action on the part of the learner if results are to be of permanent value. When it is words, words and objects, objects we can have no other result than slow, inaccurate workers and people who attend more carefully to form and process—to thinking whether to divide, multiply, add or subtract—than to letting process come naturally as the result of thought.

Perhaps the idea of form is exaggerated here. In fact, we

can reasonably suppose the work of the lower grades is better done than in the past. Yet we must conclude from the papers entitled, "Teaching Arithmetic in the Ten Cities of the United States," in this year's primary education, that there are still many who present the beginning work from the form side. In the four numbers now published only one gives the thought side a strong place in the first year's work.

As we proceed through the grade we still find the interest of the child not consulted in the formation of problems. The text from which most problems are taken seldom or never touches the life of the child. We should certainly be expecting the impossible in a book if we required the text to contain points of particular and especial interest to the children of every part of the United States. How can the writer know what local prices are used in this particular year? How can he know the line of problems the child will be interested in at this particular time? The very fact that names in the problems, the commodities bought and sold and the prices are such as he is not accustomed to make the problems abstract even though concretely worded.

The child loves to be doing. It is only in recent years that any attempt has been made to lead children to investigate things about them, to look into the enterprises of the community as a basis for many phases of arithmetical work. The visits to the grocery store, the dry goods store, the flour mill, the farm, the carpenter shop, the bank, to a host of places common to all neighborhoods, furnish an abundant fund of practical, live problems; live because the child has had a hand in gathering data for their formation, as well as practice in forming problems for solution. He has seen what problems each industry brings. He has touched the business from other than the book side. What he is getting is his work, his thought; hence real to him. Such outside work prefacing the work of the text will help make images clearer, will give a broader basis for generalization and do much to subject form-processes to thought-processes.

To gather data for the child's own problems, whether in the second or in the eighth grade, requires very little extra time. A suggestion from the teacher here and a few excursions after

school hours, a few lines of work in school will suffice to give life and color to work which may still be mostly along beaten paths.

In the matter of drill we find that much of the lower grade work, especially, has been merely repetition of forms or symbols. Rarely have points to be remembered been first approached several times from the thought side. Immediately upon presentation has followed the drill, which very often was only a jumble to the child, of meaningless abstractions. The repetition did not come as a result of some new impulse of the child. Monotony destroyed the life of the subject and made that which should be pleasurable a veritable bugbear. Instead of this the drill should be a live, inspiring, development lesson. There has been a surfeit of abstract work, such as having a child repeat again and again the multiplication and addition tables, hoping that in the mere repetition the desired end might be accomplished.

We forget that things seldom or ever find lodgment that are not the result of mind growth. Children are not machines, but each new experience must be viewed and learned in the light of former experience. Hence, in the first place, a slow approach to the point taught will be necessary; and in the second place the approach must be several times repeated from the thought side before abstract drill of any kind is given. We must lead the child to see that slowness in the manipulation of figures is a hindrance to the thought which he wishes to express. Little by little a feeling for the need of accuracy and speed will spring up and the child himself will desire the drill.

Another hindrance to the best results in grade-work is lack of continuity. Teachers of one grade know comparatively little of the work of another grade. To get the best results each teacher should look both beyond and below the actual work she is doing. She should be cognizant of how the work has been presented at the beginning and how it has been carried along until the class reaches the grade she is teaching.

Discordant ideas of what constitutes good work brings confusion into the school room. One teacher holds tenaciously to the principle that thought must predominate. She believes that the child should go no faster than he can comprehend the work. In

doing so perhaps the entire ground laid down by the course of study has not been covered. The next teacher desiring to correct this defect and not knowing the ideals of the former teacher, plunges into the form side of the work. She deals with things from the external view. What is the effect upon the child? He must in a measure reconstruct his mode of thinking. Missing the concrete, looking into things from excursions or suggestions made by his former teacher before going to the text, missing the games to enliven the drill, he tires of the never-ending figures and the talk about Mr. A. and Mr. B., and so fails to do as well as he did the previous year.

Much better work along all lines could be done if teachers of the same school would discuss with greater freedom ideal principles and modes of procedure. When all jealousies die out and all are willing learners, with the little child to lead them, what may we expect along pedagogical lines!

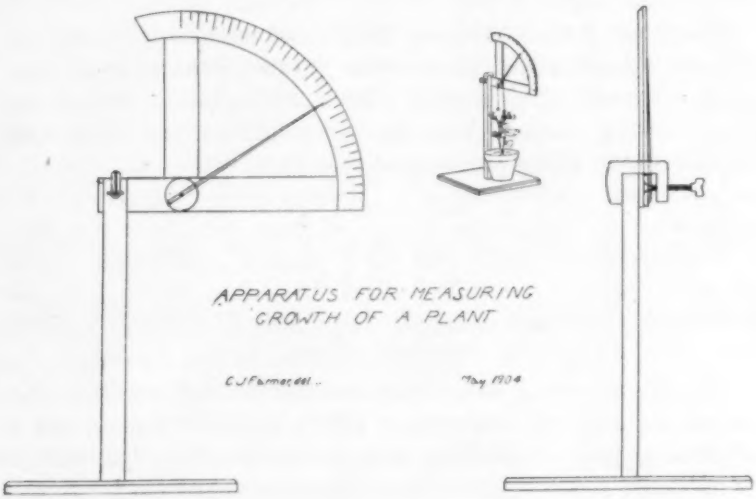
APPARATUS FOR MEASUREMENT OF THE GROWTH OF A PLANT.

George W. Low. Teacher of Sciences, Punchard School, Andover, Mass.

The accompanying drawing and sketch show the construction and use of a simple contrivance which has proved a success in elementary classes of Botany in studying the rates of growth of plants under different conditions. The apparatus was made by a boy in one of the classes from a sketch by the instructor.

A cord attached to the end of the growing stem of the plant to be studied runs up over a grooved wheel, free to rotate, to which the index pointer is attached. A small weight hangs on the other end of the cord to keep it taut. The length of the index pointer is ten times the radius of the grooved wheel. With the upward growth of the stem the pointer moves upward on the arc, which is made of thin wood and graduated. By this means the actual growth of the plant is magnified ten times. The apparatus might well be made with longer index pointer or smaller grooved wheel.

Using this apparatus students have conducted a number of qualitative and quantitative experiments. The rate of growth of a plant kept for several days in a dark place was compared with the rate of growth in the light. The influence of certain substances used in the water given the plant was determined and the efficiency of various fertilizing solutions compared. By use of this apparatus, the influence upon growth of continued artificial light could be determined. Other experiments readily suggest themselves.



It has been found of advantage to have the registering part of the apparatus attached to the upright support by means of an iron clamp rather than permanently fastened in one position. With such an arrangement studies may be made with plants in the garden by clamping the apparatus to a stake driven down firmly near the plant. In such outdoor use and in the use with potted plants in the laboratory, care must be taken that the clamped part does not become moved during the experiment.

MAP CONSTRUCTION.

BY WILLIAM H. SNYDER.

Master in Science, Worcester Academy.

Since of necessity maps must always occupy a most important part in the study of geography it seems particularly essential that the pupil should as soon as possible be taught to appreciate the methods by which maps are constructed. The writer has therefore felt that perhaps others might be interested in some laboratory work that he has been trying to do along the line of map construction. Although it is easy to understand how a plan of a flat area can be drawn, yet it is rather difficult to see how the curved surface of the earth can with any degree of accuracy be represented on a plane surface. In order that this difficulty of representing a curved surface upon a flat surface may be really appreciated by the pupil and not be a matter of simple hearsay instruction, it has been for several years the custom of the writer to give each of his pupils a cheap six-inch globe and ask him draw from it a map of North America, being careful to have it just as accurate as possible. For this purpose he has furnished the pupil with a ruler, a pair of compasses, a piece of thread to measure with, and in fact any simply contrivance which the pupil has desired. After the map has been drawn a tracing of it is made on tracing paper and the tracing held above the globe and compared with the outline of North America as seen through it upon the globe. Of course the two never exactly correspond. The pupil is then asked why they do not, and if he thinks he can hit upon some better scheme. It is always surprising how many really practical schemes of partially overcoming the difficulty will be developed by the different members of a bright class. It is rarely that three or four of the different kinds of projection are not roughly hit upon. An exercise of this kind never fails to convince the class that there must be a carefully prepared scheme if the surface of the earth is ever properly to be represented on a map and that even then it is very doubtful if it can be represented in its proper proportions. The pupils become anxious to learn what these schemes are.

There are three rather simple projections by which almost the entire surface of the earth, the surface of a hemisphere, and the surface of a particular locality can be quite accurately outlined and these projections can be easily taught.

The first of these is the cylindrical projection. In this a sheet of paper is considered as folded around the earth tangent to the equator and from the centre of the earth lines are drawn to the paper through the intersections of the meridians and parallels. Thus these intersections are projected upon the infolding cylinder and the parallels and meridians can be drawn through the projected points after the cylinder has been unrolled. The instructions given by the writer to his classes for this projection are as follows:

FIG. 1

Near one of the shorter edges of a piece of paper about 18x24 inches, draw a circle of 3 in. radius (Fig. 1.) Call this short edge of the paper A. Draw a diameter to the circle parallel to the edge A. At the centre of the circle erect a perpendicular to this diameter, cutting the circumference in two places. The circle will be divided into quadrants. Divide one of the quadrants farthest from the edge A into 9 equal parts. From the point where the diameter meets the end of this quadrant draw a tangent to the circle. The tangent will be parallel to the longer edge of the paper if the paper is cut in the shape of a rectangle. From the centre of the circle draw a line through each of the points which divide the quadrant into the 9 equal parts. Extend each of these lines until it meets, if it is possible for it to meet, the tangent line. The latitude parallels of 10, 20, 30, etc. degrees have thus been projected onto a line tangent to the surface of a sphere of which the circle is a cross-section. This line represents one side of the cross-section of a cylinder enfolding the globe and also the projection of a parallel of longitude passing through the point of contact.

Take now a piece of paper similar to that just used and near one of the shorter edges draw a line parallel to this edge. Measure on this line a length equal to the circumference of the circle of 3 in. radius (Fig. 2.) Divide the length into 36 equal parts and at the points of division erect perpendiculars, extending these perpendiculars to the opposite edge of the paper. Divide one of these perpendiculars into parts equal to the parts into which the tangent line was divided, by the lines drawn from the centre through the divisions of the quadrant. From these points erect perpendiculars across the paper. The perpendiculars will be parallel to the shorter edge of the paper if the paper is cut in the shape of a rectangle. Parallels of latitude have thus been drawn as they would be projected from the centre of a 6-in. globe onto a cylinder folded around it. There are then on the paper lines representing the projections from the centre of the globe of both parallels of latitude and meridians. Number on the line first drawn, which represents the equator, the meridians making the centre meridian 85° west. On the edge of the paper number the parallels of latitude making the equator 0°.

As will be seen the cylindrical projection causes a degree of latitude to vary from a small length at the equator to infinity at

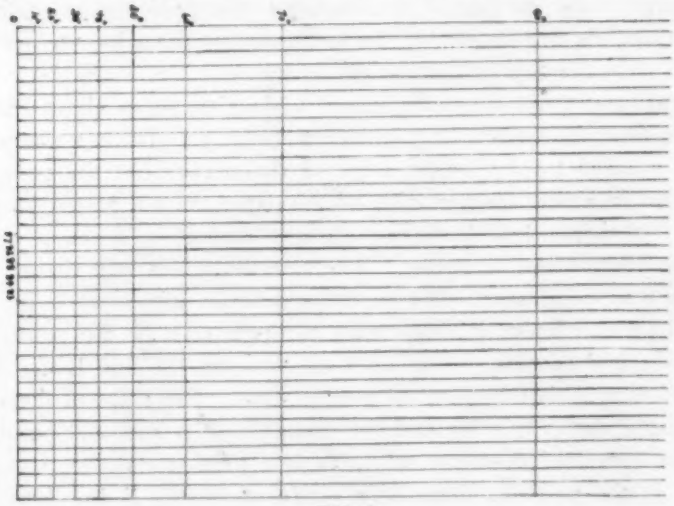


FIG. 2

the pole, and a degree of longitude which at the pole has no length is made to everywhere have a length equal to that of a degree on the equator. Thus in passing from the equator toward the poles the areas of surfaces on the earth are increased when represented on this projection, but the increase east and west and the increase north and south are not proportionate. The Mercator's projection is simply a modification of the cylindrical projection in which the exaggeration north and south is made equal to that east and west. After doing this work the pupil is actually able to appreciate why Greenland, an island which on the globe is of small size, when seen on his ordinary may of the world is about half the size of North America, and why the Dominion of Canada appears larger than the United States. The usefulness of this projection consists largely in the fact that north and south are directly up and down the map and east and west are toward the right and left.

Probably the best of the hemispherical projections for study is the Stereographic. In this projection a piece of paper is considered as held tangent at a point on the earth and from a point directly opposite this point lines are drawn to the paper through the intersections of the parallels of latitude and longitude. Through these projected intersections the projected meridians and parallels are drawn. The instructions given by the writer to his class for this projection are as follows:

Near one of the shorter edges of a sheet of paper about 18x24 inches describe a circle of 3 in. radius (Fig. 3.) Draw a diameter A B parallel to the longer edge of the paper. At the point B farthest from the shorter edge of the paper erect a perpendicular B C (7 inches long.) Draw another diameteer K K at right angles to the first diameter. The two diameters will divide the circle into quadrants. Divide the quadrant nearest B C into 9 equal parts. From A draw lines through each of the points of division and continue these lines till they cut the line B C. The line B C will then be divided into 9 parts. The point of division nearest C, letter D. Extend the diameter A B and at a point H on the extended diameter which is at a greater distance from B than is the point D describe a circle of radius B D. Draw a

diameter at right angles to the line B H. Letter the points where the diameter cuts the circle N and S. Extend the line B H till it cuts the large circle at a point E. The extremity of the diameter nearest B, letter W. The large circle has now been divided into quadrants. Divide each of these quadrants into 9 equal parts. Divide the radia W H, N H, E H and S H each into parts similar to those into which the line B D was divided. In each case the division nearest B should lie next to the centre H. Beginning at the points N and S number the divisions of the circle on either side of these points in even tens from 90 to 0. The line W E in each case will be 0. Number the divisions of the lines W H and E H in the same way.

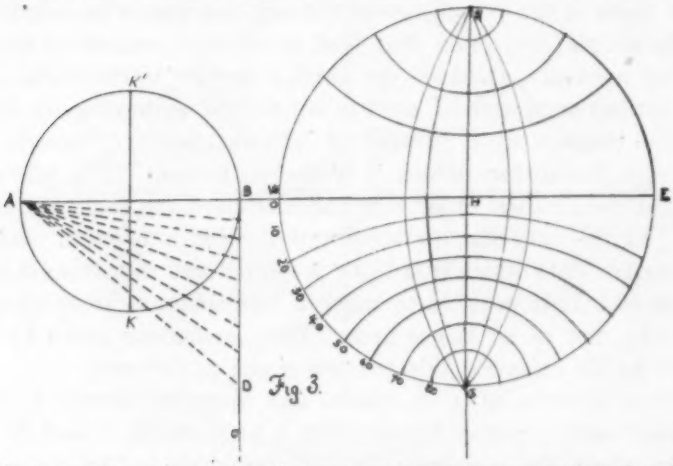


Fig. 3.

Placing one leg of a pair of compasses on the extended line N S draw arcs of circles through the three points on each side of the line W E, which are numbered 80, 70, etc. These arcs will be the projections of the parallels of latitude. Placing a leg of the compass on the line W E or its extension, draw arcs of circles through the points N, S, and each of the divisions into which W H and E H have been divided. These arcs are the projections of the meridians. Taking one of these meridians as the prime meridian, number the meridian from 0 to 180.

It will be seen that in this projection places near the point of tangency have their outlines correctly reproduced, but that the

farther away a place is from this the greater the distortion. This distortion, however, is never as great as that at the north and south on the cylindrical or Mercator's projections. Here, however, the directions north and south and east and west must be traced on a curved line, thus making it much more difficult to tell at a glance the direction of one place from another. Also it is not possible on this projection to show more than one-half of the surface of the earth on a single map. This projection or a slight modification of it is the one most often used for hemispherical maps, and from its study the pupil is able to understand why it is that countries near the centre of these maps are almost exactly of the same shape as when seen on the globe, while those at the extremities of the map are somewhat distorted.

The simple projection that best shows the method of representing a small section of the earth's surface is the conic. In this projection a conical shell is considered as having its inner surface tangent to a parallel of latitude passing through the centre of the surface which it is desired to map. The intersections of the parallels of latitude and meridians are projected upon this. In this way the surface for projection is brought near to the surface onto which it is to be projected and distortion is thus decreased.. It is possible to make a hemispherical projection in this way, but of no larger area. The instructions given by the writer to his class for this projection are as follows:

Draw a circle of 4 in. radius and from the centre C of a diameter erect a perpendicular (Fig. 4.) Mark by N and N′ the points where the perpendicular cuts the circle. The circle has been divided into quadrants. Bisect the two quadrants that lie on the N side of the diameter and letter the points of bisection P and P′. At the points P and P′ erect perpendicular to radii drawn through each of these points. Extend these perpendiculars till they intersect each other at a point on the extended line C N. Letter this point H. Extend the line H P to a point I, making the distance P I nearly equal to the distance H P. In a similar way draw the line H P′ I′. The lines H I and H I′ are tangent to the circle at a point 45° from the diameter. Divide the quadrant that passes through the point P into 9 equal parts.

On either side of the point P *mark off* on line H I distances *equal* to the distances along the arc from P to each of the divisions into which the quadrant was divided. Use a pair of compasses and consider the cord of a small arc equal in length to the arc. The diivsion farthest from H letter M. On the line H I′ mark off the distance H M′ equal to H M. M M′ is the diameter of the base of the infolding cone. The divisions of the line H I are

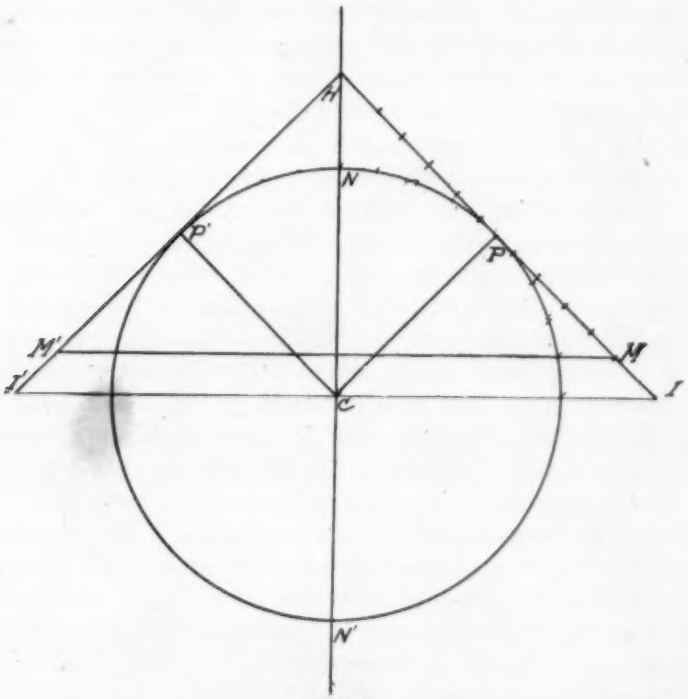


FIG. 4

the equidistant projections on the tangent line (which is a side of a cross section of the conical shell) of each of the even ten degrees of latitude.

On a large piece of paper describe a circle with a radius equal to the distance H M of Fig. 4. This circle is a curve similar to that formed by the perimeter of the conical shell when unrolled and flattened out. Letter the centre of this circle D (Fig. 5.)

From a point on this circle *measure* off a distance equal to the circumference of the circle of which the line M M′, the diameter of the base of the infolding cone, is the diameter (— 3.14.) Mark the extremities of the distance A and B. The arc A B is the perimeter of the unrolled and flattened-out conical shell. Divide the distance A B into 36 equal parts. These divisions are the projections on the perimeter of the cone of the meridians

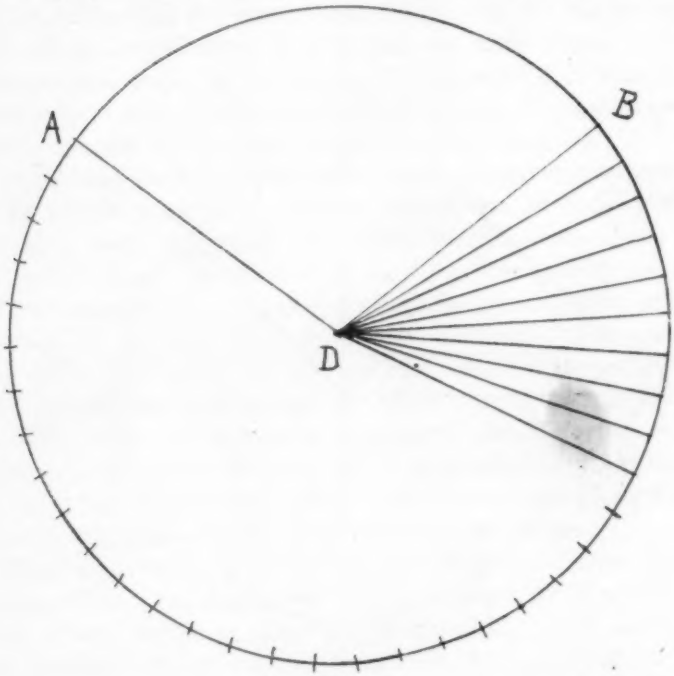


FIG. 5

of each ten degrees of longitude. From D draw lines to these divisions. The lines are projections of the meridians on the infolding conical shell. Using the distances from H to each of the divisions of the line H I as radii, inscribe about the point D arcs of circles which shall cut all the meridian lines which have been drawn between the lines D A and D B. These arcs will be the projections of the parallels of latitude. Beginning with the arc nearest the point D number these parallels of latitude

in even tens from 90 to 0. Taking any one of the meridians as a prime meridian, number the meridians on each side of it from 10 to 180. The meridians and the parallels of latitude have thus been projected onto the inner surface of an infolding conical shell and the conical surface laid flat. The conical surface was made tangent at 45°.

It will be seen that in this projection the exaggerations east and west are practically the same for equal distances north and south of the line of tangency, and that the north and south exaggeration is not great. Here, however, the directions east and west follow curved lines and those north and south straight lines, but these straight lines are not up and down the map. Thus it is difficult to tell without rather careful inspection the direction of one point from another. A modification of this projection is the one generally used in making maps of countries and grand divisions. In order that the characteristics of map projection may be better appreciated the writer is accustomed to give each pupil a list of the latitudes and longitudes of the prominent points around the outline of one of the grand divisions and have dots made for these on each outlined projection, and afterwards the dots connected thus giving an outline map of a grand division on each of the projections constructed. This does more than simply help to show the characteristics of the projections; for it teaches latitude and longitude which somehow is a terra obscura to the average boy and girl. Theoretically most of them know what these terms express, but they have no practical realization, and many of them when writing the longitude of the meridians have no idea of stopping the upward progress of their numbering at 180 degrees or of allowing the pole to stand as simply 90 degrees.

That this sort of work is both most interesting and instructive has been the writer's experience with classes during the past five or six years. It clears up the appearance of vagueness and unreliableness which maps are likely to have, since the same country may have a different shape when seen represented on different maps. It also gives a definiteness to geographical work which is liable to be lacking. It removes the idea which seems

to be inherent in the mind of the boy or girl coming from the lower schools that north and south must be up and down and east and west to the right and left. Maps become something more than devices for showing directions and for measuring out distances which are often found to be wrong, with a wrongness which is generally assigned to carelessness of construction, whereas it may be due to an inherent characteristic of the map. Maps thus cease to be considered as haphazard representations and become definite and skilfully devised efforts to represent as nearly as possible that which it is impossible to represent exactly. They have a real scientific interest and geography itself appears more as an exact science.

A GRAPHICAL REPRESENTATION OF THE PERIODICITY OF THE CHEMICAL ELEMENTS.

By Wilhelm Segerblom, Instructor in Chemistry, Phillips Exeter Academy.

An article in a recent number of School Science on a lecture table device for illustrating the periodic system of the chemical elements puts me in mind of a little graphical device I have used in the class in second year chemistry when trying to show the periodic recurrence of certain properties of the elements.

In a detailed study of Mendeleeff's Table with the class the following facts are brought out:

(1) From Group I. to Group VII. the metallic character decreases.

(2) From Group I. to Group VII. the acid character increases.

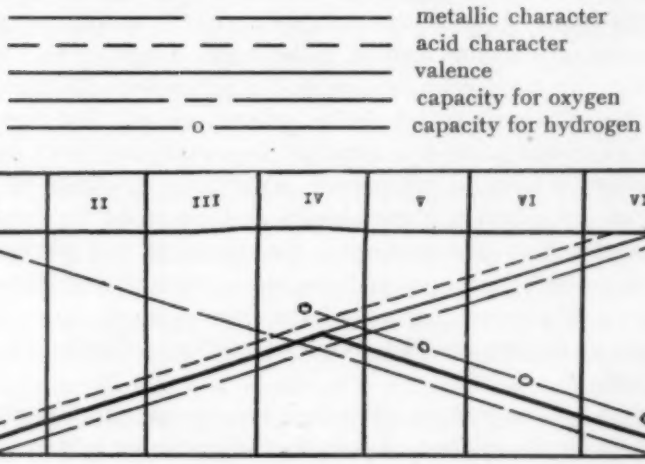
(3) The valence increases from Group I. to Group IV. and then decreases to Group VII., except in a few cases in Groups V. to VII. where there is a continuation of the increase found in the first four groups.

(4) The capacity for oxygen increases from Group I. to Group VII.

(5) The capacity for hydrogen is nil in the first three groups,

starts with its highest value in Group IV., and decreases to Group VII.

When the above points have been brought out clearly and illustrated by numerous examples, and the general formulae for the oxides and hydrides have been developed the whole is recast in crystallized form in the following diagram:



The specific gravity is not included in the above diagram because that rises in the even short series and falls in the odd short series, and is therefore shown best in a long series table where the Li and Na series are separated as on page 168 of Nernst's Theoretical Chemistry. If in such a table the specific gravity of each element be written directly under its symbol, then it becomes very apparent that the specific gravity is highest in the so-called Group VIII. and falls gradually toward both ends of the long series.

This graphical device helps greatly in presenting the periodicity of the elements in concise form, but I have not seen it worked out in any text-book on Descriptive Chemistry.

THE TEACHING OF ALGEBRA BY THE LABORATORY METHOD. II.

CHARLES W. NEWHALL, HEAD OF MATHEMATICAL DEPARTMENT, SHATTUCK SCHOOL, FARIBAULT, MINN.

In a previous paper under this title I attempted to show that a familiarity with symbols, type-forms, and algebraic formulas is the foundation of the study of algebra. In the application of the laboratory or inductive method to the study of algebra we attempt to secure this knowledge, always by the principle of the transition from the individual notion to the general notion. But there are many algebraic processes more or less elaborate, such as the extraction of roots of polynomials, clearing an equation of fractions, etc., in which it is not so easy to discover, by the inductive method, the laws that govern, or the steps that will produce the desired result. But even in these more involved operations the student will acquire a grasp of the process much better by an attempt to develop his own solution, than by a slavish following of a rule.

Often he can use to advantage a mode of attack similar to that used in the solution of construction problems in geometry—imagine the problem solved, and try to discover what steps were necessary to attain that end. It is not hard to develop the method for the extraction of cube root or for the solution of quadratic equations in this way. Or, again, he can secure a desired result in a sufficiently simple problem, and then extend his method to cover more complicated cases. It is easy to clear an equation of fractions, and to prove the equivalency of the resulting equation when the denominators are all monomials; and it is equally easy to extend the method of fractions having polynomial denominators.

By keeping the desired end always in view, insisting on the *object* of each step being made clear, and its *legitimacy* proved, I see no reason why this work should offer more difficulty than the solution of original exercises in geometry. The student must be taught to discriminate between a device that will work in a particular problem, and a method that is general enough to apply

to all problems of that class. If a device or method of solution is found to be general enough to have a frequent application, require him to dignify it with a formal statement, writing a rule for that operation in words, and, if possible, also in symbolical language.

In order to illustrate how the steps of a given operation may be developed according to the inductive method, let us imagine a class beginning the study of the solution of a system of simultaneous equations. The teacher presents to the class the equation $3+5y=21$, and asks them if it is possible to find a numerical value for y, and another numerical value for x so that the sum of 3x and 5y shall equal 21? The teacher suggests that x might equal 1. A bright pupil discovers that if x does equal 1, and y equals 3 3-5, the equation will be satisfied. The teacher then suggests that x might equal 2. It is soon discovered that if x equals 2, and y equals 3 the equation will also be satisfied. It is now easy to construct a table of the corresponding values of x and y, any pair of which will satisfy the equation; and the class notes that there are an indefinite number of sets of values of x and y that will reduce the equation to an identity. A second equation. Say, $7x-2y=8$, is then proposed, and the class joins in eagerly to find a similar table of values of x and y that will satisfy the second equation, and finds there are an indefinite number of pairs of values for x and y to satisfy the second one.

The crucial question is then put: "Of all the pairs of values of x and y that will satisfy the first equation, and of all the pairs of values that will satisfy the second, are there any pairs of values that will satisfy both equations?" The students glance hastily through their tables and find that $x=2$, $y=3$ will reduce to identities both equations. These values, on being substituted, verify in each equation.

It is then made clear that any pair of equations, both involving the first powers of x and y, can *both* be satisfied by but one value for x and one for y. The meaning of the word simultaneous as applied to equations is now brought out. If we similarly find a table of values for x and y in a third equation, we will find a pair of values corresponding to one pair of values in the first and a dif-

ferent pair in the second, but no pair of values common to all three.

We can extend our scheme to show that to find values for n unknown quantities we need n equations, no more no less—fewer than n equations would be insufficint, more, would demand an impossibility. The meaning of indeterminate and overdetermined as applied to equations can now be shown, and other facts about systems of equations be deduced, as, for instance, the fact that our equations must be independent.

The same points may be made by the use of the graph, and I think such notions, to a limited extent, may well be introduced at this point.

The student is now aroused to see the necessity for a less cumbersome solution, and is led to observe how simple it would be to find values for x and y, if one of the equations could be replaced by an equation in which only one unknown quantity occurs. The method of elimination by addition and subtraction is then developed step by step, each step of the process being justified, not by the use of axioms, but by the principles of the equivalency of equations, which are already familiar from their use in connection with linear equations. The only new principle that need be established in this connection is that, given a system of equations $\left\{\begin{matrix} a=o \\ a'=o \end{matrix}\right\}$ this system will be equivalent to the system $\left\{\begin{matrix} ma+na'=o \\ a=o \end{matrix}\right\}$ When the values of x and y have been found by this method for a given pair of equations, their correctness is verified by substitution, the generality of the process proved, and a formal statement of the different steps of the process is drawn up in words.

A method of attack like the one described will require some time, perhaps, but I think it will be time well spent. We do not only want to teach how to solve a pair of equations to obtain the values of x and y, we want to bring out all the notions in connection with systems of equations that have been referred to above, and others. We want our students to see the necessity for, and the reason in, each step; and to be able to prove the correctness of everything they do. We want them to appreciate the meaning of their results when they reach them. "If

we do not insist upon a thorough understanding of the principles involved, the solution of equations will resolve itself into the going mechanically through a certain regular process which in the end gives the answer." Some teachers require the student to explain how each step is obtained from the proceeding. This is good, but the "why" is better than the "how," as Mr. Smith puts it in his book on "The Teaching of Elementary Mathematics."

The reason for insisting, as above, upon the necessity of justifying the successive steps of our solution by reference to the principles of equivalency, instead of quoting, as authority, certain axioms, is that a too blind dependence upon the axioms may lead to trouble. In the solution of radical equations, and indeed in other equations, the student obtains "answers" that will not verify. If he understands the principles of equivalency his faith will suffer no shocks. But what is the student to do who solves questions blindly by axioms and does not know the meaning of equivalent equations, when the only answer he can find for an equation will not verify, as will be the case in $\sqrt{x-5}=1-\sqrt{x-2}$

Such a thorough grasp of the processes of algebra can be attained, I think, even by elementary students, by the use of the laboratory method. Of course the teacher must do his share. He must stimulate them to think, and direct their efforts by judicious questions and suggestions. The plan of attack must be clearly outlined in the teacher's mind, and he must develop each subject logically and slowly.

Professor Hanus has this to say in connection with the idea of acquiring first the individual notion and proceeding from that to the general notion. He is speaking of the teaching of geometry, but what he says applies with equal force, I think, in the teaching of algebra.

"Now there are two ways of applying this principle in practice: 1st, by continuous exposition; 2d, by questioning. The first can be advantageously employed in the instruction of advanced youth and of adults, very rarely in teaching children, for which purpose the second way is to be employed as much as possible.

"The teacher's skill in applying this principle—i. e., the number of rational devices he will employ—depends upon his grasp

of the logical structure of the subject and upon his power to study his own mind and the mind of his pupil. Knowing the logical structure of the subject he will present the steps of every part and all the parts in their proper sequence, and so as to bring out their proper relations. His ability to study mind will enable him to ascertain the mental process the pupil must undergo to master the subject, and to present the subject step by step in harmony with these processes."

To make a more complete application of the methods of the laboratory to the teaching of algebra, we might make use of some of the devices and arrangements before referred to as externals, which are peculiar to the laboratory studies. We could use measurements and models to some extent, work practical problems, and aim to keep the subject as concrete as possible. The use of the graph, and other correlations of geometry with algebra would help very much.

And again we could emphasize the idea of individual work. I should fear, however, that a class would lose a great deal by being cut off too largely from the stimulus of class work. As a compromise that would eliminate some of the disadvantages of purely individual work, and secure the desirable features of class recitations, I would like to meet my class for two periods a day—once for recitation and once for study. The lesson would be developed in the recitation period and the students would work independently under the teacher's eye in the study period. Thus individualism could be secured and genius not stifled. The brighter students could be encouraged to do more work, and if possible to branch out into investigations on their own account.

To stimulate work of this kind assignments might be made to various authors, along the line of some subject in which the student shows interest. In this connection a small well chosen library in the class room would be an excellent thing. The students would be urged to use it freely under the guidance of the teacher. There might be on the shelves several of the best text books, as well as other books not beyond their comprehension, or even some which were beyond them to provide, perhaps, an

incentive to more advanced study. I am sure some students would read for their own pleasure parts of such books as:

Ball's, "Mathematical Recreations and Problems."
Schubert's "Mathematical Essays and Recreations."
Smith's "Teaching of Mathematics," and
DeMorgan's "Study of Mathematics."
Fine's "Number System of Algebra."
Fink's or Ball's "History of Mathematics."
Heath's "Series of Mathematical Monographs."
Dobson's "Pillow Problems," Flatland, etc.

COMPOSITION OF MOTIONS.

ALBERT B. PORTER, CHICAGO.

It would be hard to devise a more useful piece of apparatus for illustrating the composition of motions than a narrow strip of elastic rubber (a broken rubber band) with a small ball of white paper tied to it at some point. In fig. 1, let the plane of the paper represent a blackboard and let the ends of such a strip of rubber be held against the blackboard between the fingers of the two hands at a and b, the rubber being held in a state of tension. Let c represent the ball of paper whose motion is to be studied. If the end a of the rubber strip is held stationary while the end b is moved along the surface of the blackboard following the line bb' the paper ball c will move along the line ce. If, on the contrary, b is fixed and a is moved to a', c moves to d. If now a is held fixed and b is moved to b' and remains there while a is now moved to a', the paper ball traces the path cec'. Again, recurring to the original position of the rubber band, if b is fixed while a is moved to a' and then b is moved to b', the paper ball traces the path cdc'. Finally, starting with the original position, if both ends of the band are moved simultaneously from a and b with such speeds that a' and b' are reached at the same instant, then the paper ball traces the diagonal path cc'. By having the lines aa', bb' and the parallelogram $cdc'e$ and its diagonal drawn on the blackboard beforehand, according to the construction which is obvious from the figure, one is prepared to show a most simple

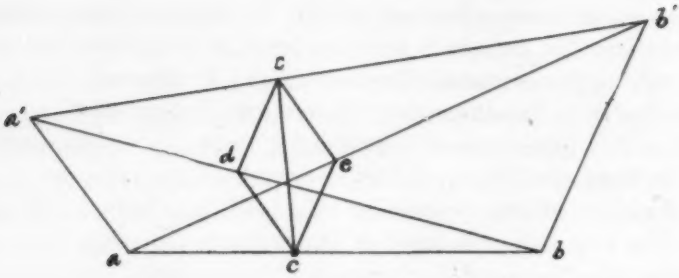


FIG. 1

and striking illustration of the composition of successive and simultaneous motions. The experiment is one whose teaching value is high because of its simplicity and directness. It is perhaps best in this experiment to tie the paper ball to a point some distance from the centre of the rubber band as indicated in the figure.

If the paper ball is tied to the middle of the band, and the experimenter faces his audience, holding the ends of the band in his two hands, he is prepared to illustrate in a very simple manner some of the essential facts in connection with the composition of simple harmonic motions. In fig. 2 let ab represent the rubber strip and c the ball. If a is held stationary and b moved back and forth between b' and b'', c moves between c' and c'' with

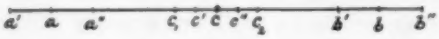
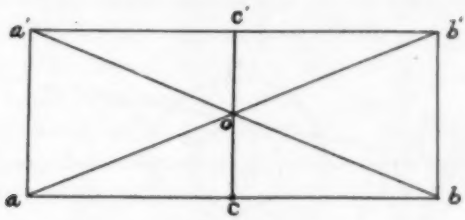


FIG. 2

a vibratory motion whose amplitude is one-half that of b. Similarly, c traverses the same path if b is fixed and a is moved between a' and a''. If both hands are moved so that the motions $a'\,a''$ and $b'\,b''$ are always in the same direction, then c moves with double amplitude over the path $c_1\,c_2$. Finally, if the hands are always moved in opposite directions, the point c remains stationary, thus showing the destructive interference of equal simple harmonic motions whose phases are opposed.

Another illustration of the same principle may be obtained by moving the hands vertically as indicated in fig. 3, instead of

horizontally. If the motions aa' and bb' of the hands are in the same phase, the ball traverses the path cc'; if, however, the hands move in opposite phases one moving down while the other moves up, c remains stationary at the point o.



FIF. 3

With a little practice one can also illustrate the composition of two rectangular harmonic motions as indicated in fig. 4. With a stationary and b moving between b' and b'', c traces the path de. With b stationary and a moving between a' and a'', c moves between f and g. If the hands start from the positions a' b', and move in the same period over the former paths, then c will trace

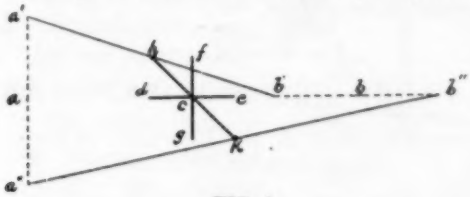


FIG. 4

the diagonal path hk. If the observer can by practice acquire sufficient skill to keep a difference of phase of 90° between the motions of the two hands so that the points a and b', a'' and b, etc., will correspond, he will be able to show the resultant circular path of the point c. He will thus be able to illustrate the origin of circularly polarized light from the union of two plane polarized beams.

Figure 5 shows how the rubber band may be used to illustrate the composition of circular motions. With either end held stationary and the other traversing one of the circles a' or b', the paper ball will trace the smaller circle c'. If the ends of the

band are made to traverse the two circles a' and b' both in the same direction and in the same phase, c will trace out the larger circle c''. If, on the contrary, the motion of the circles a' b' are in opposite directions and so timed that the hands pass through the highest points of the two circles at the same instant, then c will traverse the vertical straight line de. The introduction

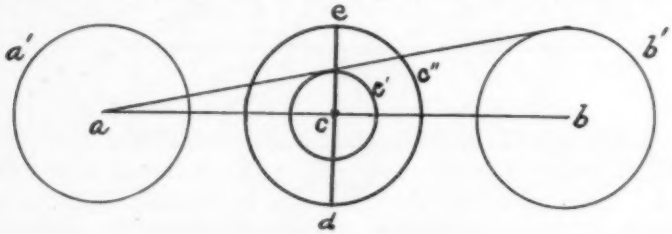


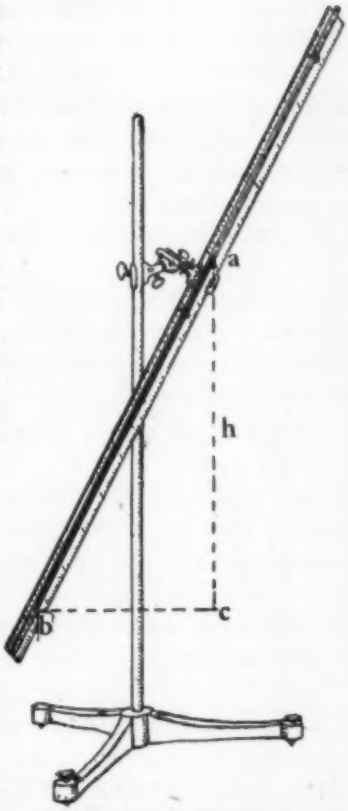
FIG 5

of a slight difference of phase will cause the line de to incline to one side or the other. This experiment enables one to illustrate not only the union of two circularly polarized beams to produce plane polarized light, but also to illustrate the rotation of the plane of polarization in quartz, etc.

BOYLE'S LAW, BY MEANS OF A CAPILLARY TUBE.

C. H. Perrine, Instructor in Physics, Wendell Phillips High School, Chicago.

The apparatus consists of a capillary tube one meter long with a bore of about one millimeter, sealed at one end and fastened to a meter stick with wires at three points. In the tube is about three centimeters of air and sixty centimeters of mercury. The meter stick is clamped to a table stand so as to move around a horizontal axis and to have its broad side facing the operator. The tube may be filled before sealing if care be taken to secure the proper amount of air while closing. This should be done by the teacher. The pupil should be given the tube mounted on the meter stick ready for work. The tube should always be handled with care and never taken from the meter stick on which it is mounted.



In working the experiment first hold the tube vertically with sealed end down and note the volume of the enclosed air. Then slowly invert it to a verticle position with the open end down, noting the change in the volume of the enclosed air. When the reason for the change in volume is clearly understood, i. e., how the change in position affects the pressure on the enclosed air, the pupil is ready to work for data to determine the law. The temperature of the enclosed air should remain constant throughout the experiment. The volume of the air is read directly from the stick. The pressure is obtained by adding to the barometer reading the verticle distance or height of the end of the mercury toward the open end of the tube (a) above the other end (b) of the mercury column (*a c* or *h* in Fig. 1). When the closed end is down *a c* or *h* becomes a negative quantity. The general equation then is $P=H+(a-b)$. *P*, being the total pressure, *H* the barometer reading, *a*, the distance of open end of mercury column to the table and *b*, the distance of closed end of mercury column to table, *a c* being determined by measuring the distances of *a* and *b* from the table.

Begin with the closed end down. The change in volume for the first few times should not be more than one centimeter. Take at least twelve readings in turning from one vertical position to the inverted position.

Plot from the data results as follows:

"*A*" with *V* on *Y* and *P* on *X*.
"*B*" with *V* on *Y* & 1-*P* on *X*.

It will be noted that the "*B*" results give a straight line which should pass through zero. If it does not pass through this point and the work has been carefully done, the horizontal distance will indicate the correction that should be given to the readings of the barometer.

DATA.
H=76.5 cm.

V.	h	$\frac{P}{H+h}$	$\frac{1}{P}$	V P.
2.8	62.8	139.3	.0070	408
4.	25.9	102.4	.0099	410
5	6	82.5	.0120	403
5.4	0	76.5	.0130	413
7	−17.5	59.	.0168	413
10	−34.6	41.9	.0238	419
13	−43.9	32.6	.0306	424
15	−48.1	28.4	.0352	440
17	−51.1	25.4	.0399	434
20	−54.8	21.6	.0462	432
22	−56.7	19.8	.0513	436
24	−58.3	18.2	.0559	438
26	−59.9	16.6	.0605	432
28	−62.8	14.7	.0650	423

REPORT OF THE COMMITTEE ON BIOLOGY*

1. The committee recommends that a full year, not earlier than the second year of the high school, be devoted to zoology alone or to botany alone and not a half year to each.

2. As a prerequisite to the course here contemplated it is desirable that the pupil should have a year's training in elementary science in which familiarity with laboratory methods, and some knowledge of elementary physics and chemistry have been acquired.

3. Six periods per week should be a minimum of time

* Appointed by the Biology Section of the Central Association of Science and Mathematics Teachers to consider the course in Biology in the Secondary Schools.

required. These should be arranged so as to give two double periods for laboratory or field work and two single periods for recitation, lecture, or quiz.

4. A fair apportionment of the pupil's time should be devoted to:

(a). Laboratory work.

(b). Field work.

(c). Text book, recitation work, and supplementary reading.

5. Field work is held to be a necessary and important part of the course and may be arranged under two heads:

(a). The teacher should lead his class bi-weekly into accessible vacant lots and open fields and teach them how to observe and to do field work properly; this of course to be limited to autumn and spring months.

(b). Mimeograph copies of outlines and directions may be given to pupils and much efficient individual work may be done. While this kind of work may not be made a uniform requirement, pupils may be encouraged to do it and due credit given to all who do the work. Written reports of this work are to be rendered to the teacher and such time devoted to them in class as may be necessary to maintain a lively interest.

6. There should be a fair proportion of attention given to morphology, physiology, ecology, and economics. A knowledge of structure is of little value except it be correlated with a knowledge of function and both function and structure are of fundamental importance in relating the organism to its environment. Economics undertakes to correlate the various aspects of animal and plant life with human welfare.

7. The study of zoology or botany should be begun at the most accessible point in preference to the method usually regarded as more logical, viz., that of proceeding from the simplest forms and successively to the more complex. Accessibility is to be determined by the conditions, the previous knowledge and training of the pupils, and the desirability of a minimum use of unfamiliar apparatus and technical manipulation at the outset. Moreover, the plan of the course should be such that subjects which

afford good opportunities for field work may be considered at a time when observations can readily be made in the field and such subjects as are less adapted to field work at a time when outdoor work is not possible.

8. Wherever possible a plot of ground should be available for use in connection with the course. When established and cared for in the proper manner such a plot, even though of small size and in the city may be made to contain an abundant and varied fauna and flora of wild species and thus will afford opportunity for closer observation and study of many forms than is possible in field excursions.

9. The committee also recommends that zoology and botany be accepted as science for college entrance requirements.

10. Lastly, the committee recommends that a similar committee be appointed for the coming year to consider and report at the next meeting on such phases of this subject as may require further consideration. In this connection attention may be called to the desirability of formulating in some detail a plan of work for both zoology and botany which shall indicate the season most suitable for the various phases of the work, the length of time to be apportioned to the various subjects, etc. While such a plan can at best serve only as a general guide and much must be left to the judgment of the teacher, yet the committee believe that it would be of value in many ways.

BACTERIOLOGY IN PUBLIC SCHOOLS.

By Wilfred H. Manwaring, M. D., Department of Pathology and Bacteriology, University of Chicago.

The history of early Europe impresses the student of hygiene, not so much with the poetry of certain centuries, as with the ravages of epidemics, the horror of disease and the disregard of sanitary laws that characterized the same periods. Few realize today that in the earlier centuries the average length of human life was less than twenty years, and infectious diseases so common that every third man was marked with smallpox.

Gradually there has been an improvement. Great epidemics

have become unknown, disease and suffering have lessened, and human life has increased to an average of over 33 years.

This improvement has been due to many factors, such as better housing, better food, better habits. But the most prominent factor bringing about this change has been the rise and diffusion of correct ideas concerning the nature of disease.

The effect of such knowledge on the health of a community is nowhere more strikingly shown than in the results of recent educational campaigns against tuberculosis. In Massachusetts and New York City, where active measures have been taken to teach the consumptive the nature of his disease and to point out to him the ways in which he may become a menace to others, the death rate from tuberculosis has decreased, till it is today but slightly over half what it was twenty years ago. While in communities in which this educational warfare has not been carried out, the death rate from this disease has remained practically unchanged.

Seeing this result of popular knowledge, hygienists have dreamed of a future in which an adequate number of medical facts shall be known by all, in which disease and suffering shall be reduced two-thirds, and human life increased to the 50 or 60 years that is man's natural heritage. And dreaming thus, they have asked how this diffusion of knowledge can be brought about.

There are many ways in which medical facts can be put before the people. Lectures by medical men, house to house talks by sanitary workers, the distribution of literature. All are valuable. But they reach the people when it is too late for the full benefit of such knowledge, and they come equally emphatic with the wonders of somebody's cure-all, the marvels of another's special therapy, and all the clamor and nonsense devised by avarice and ignorance. To be efficacious, this knowledge must come early in life, and must reach the public through the mouth of authority.

There exists today such a means of reaching the people, a means thus far almost overlooked in the great world-fight against disease. This is the public high school. It deals with man midway between childhood and maturity, when interests are keen,

impressions vivid, and the mind already trained to question and answer why. The primary and grammar schools come too early. The most that can be done in them is to state the simpler facts. The college comes too late. It is of use mainly as a means of training teachers for this work. A prominent educator has said that "the public high school is the most efficient means for the uplifting of the human race." In no way is this more true than in the fact that the high school is the best means for the diffusion of medical knowledge.

The high school being the point of attack, one asks what sort of instruction should be given here. A number of years of observation and experience with high school students convinces me that what is needed is something radically different from the text-book physiology and hygiene now given our boys and girls. There is needed a virulent subject, one that will lend itself to the strength of the student and leave in his mind facts that he himself has proved and for which he is willing to fight.

Such a subject is bacteriology. In the few high schools in which it has been tried, it has been found to be all that could be hoped for it.

The work in bacteriology that should be attempted in a high school, differs from that of the college or medical school. Just what will prove of most value here can be determined only by experience. There are numerous simple experiments, however, each bearing on a large question of preventative medicine, that could profitably form part of such work. Among them are such experiments as the demonstration of bacteria in air, water, and milk; as testing the effect of heat, cold, sunlight and antiseptics on germs; and as showing the bacteria-killing powers of gastric juice. Most of these experiments have already been tried with pupils of high school grade, and have been found to be of practical educational value.

To give such work requires little apparatus not now possessed in the average high school. It does require, however, a special training now possessed by but few secondary teachers. The opportunities to acquire this training, however, are so good, and the training itself requires such a small outlay of time and effort,

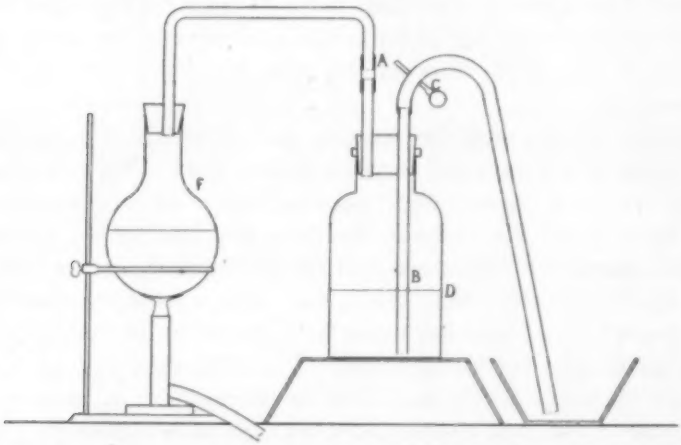
that no school board is justified in not demanding it of its teacher of hygiene.

When bacteriology finds its true place in the curriculum of the secondary school, the curves of death, of sickness and of suffering will show a downward tendency, unprecedented in the history of civilzation.

INFLUENCE OF PRESSURE ON THE BOILING POINT.

BY J. A. GIFFIN.
Collegiate Institute, St. Catharines, Ont.

In addition to the two well-known methods which are recommended in text-books of elementary physics to show that the boiling point of water is dependent upon pressure, the following simple experiment, which I have devised, illustrates the principle very clearly and does away with the necessity of using the air pump.



The accompanying figure will explain the experiment. Two persons will be necessary to do the work properly. A flask, a bottle with a wide mouth (a quinine bottle does very well), a piece of glass tubing, a piece of rubber tubing, a clamp and a small dish to catch the surplus water are all that is necessary for this experiment.

Pass one end of the glass tube through the rubber stopper in the flask and the other end just through the double perforated rubber stopper in the bottle. It is best to have at least one joint in the glass tube (as at *A*) so as to prevent breaking when handling. Through the other perforation pass a glass tube which will reach to the bottom of the bottle and to the upper end attach a piece of rubber tubing with a clamp (*c*) quite near the stopper. Leave the clamp open and remove the stopper (with the tubing attached as in the figure) from the bottle. A piece of glass tubing connected with rubber tubing to the glass tube *B* would do, but it must be long enough to reach below the bottom of the bottle.

Boil the water in the flask. Hold the stopper of the bottle in the hand until the steam passes out vigorously. Then fill the bottle with water and put the stopper in tightly as shown in the figure. The steam will force water out through the tubing *B*. When water is forced out as far as the point *D*, close the clamp (*c*) and *at the same instant* withdraw the lamp from beneath the flask. The water in the flask must be kept boiling vigorously while forcing water out of the bottle so as not to allow air to pass back into the bottle through the tube *B*, as this will spoil the experiment.

After withdrawing the lamp, or gas jet, steam condenses and the water in the flask will continue to boil from three to five minutes. When it ceases to boil pour a tumbler of cold water over the flask, wnen the water in the flask will boil again. After it ceases pour more cold water over the flask and *the water remaining in the bottle will boil vigorously*. This is more remarkable as the water in the bottle has never been heated to the boiling point, but has become hot by the steam. The temperature of the water in the flask and bottle may then be determined, or to be more accurate, a chemical thermometer may be passed through a perforation in the stopper of the flask, or bottle, at the beginning of the experiment and the temperature obtained. If the experiment fails it may be repeated a number of times in a few minutes by filling the bottle with water.

I have repeated the experiment a number of times to discover the causes of failure and have found that: (1) The experimenter

must be absolutely certain that all air is driven out of the flask before it is connected with the bottle; (2) the bottle must be full of water; (3) if one gas jet does not give sufficient heat two must be used. I have found it better to use two in every case. If cold water is used in the bottle the steam condenses very rapidly and a short time elapses before the water is forced out. (4) The result is obtained more easily and more quickly by using hot water in the bottle. (5) The experiment may be varied by throwing cold water over the bottle after the water in the flask ceases to boil when it will boil again. (6) I have not found it any advantage to have the thermometer placed through the stopper when doing the experiment. The result obtained is much below the temperature obtained by the usual text-book methods.

Notes.

Teachers are requested to send in for publication items in regard to their work, how they have modified this and how they have found a better way of doing that. Such notes cannot but be of interest and value.

METROLOGY.

New Metric Chart.—The Bureau of Standards at Washington, through Director Stratton, is preparing for the use of teachers a metric chart. Its size is 7x11 dm. It contains a meter subdivided, and, for comparison, a yard measure; metric tables and tables of equivalents in English measure for each metric unit and in metric measure for each English unit; diagrams of decimeters and centimeters—linear, square and cubical—and figures to show the relation in value of the kilo to troy and avoirdupois pounds, of grams to ounces, scruples and drams, and liters to liquid and dry quarts. As a whole, the chart strikes us as excellent. The educative value of such charts are immense, and they should be hung on the wall of every schoolroom and workshop. The best chart, like the best teacher, is the one that tells its story in the simplest and most impressive manner.

The Decimal Association of England is also preparing a metric chart for distribution. Among others, one of the best was issued years ago by the American Metrological Society; there is also a mounted one handled by the Library Bureau of Boston. The only low-priced metric chart at present on the market is sold at 10 cents by Biggar, Samuel & Co., Toronto, Can. In England are Bacon's, of several sizes; Philips', large and elaborate, and Bopp's (published in Germany), regarded by some as the best. R. P. W.

In the House of Peers.—The metric bill lately introduced into the House of Lords has passed the second reading and been referred to a select committee. The gist of the bill is that after April 5, 1906, all contracts involving weights or measures entered into by parties in the United Kingdom shall be made in terms of the metric system, otherwise they shall be void. The introduction was followed by great numbers of favoring petitions from county and town councils, retail traders' organizations, trades unions, teachers' associations and individual signatures, which attest the zeal and organization of the Decimal Association, through whose efforts this movement has been brought about. In speaking on the bill, Lord Kelvin said: "Of the objections raised against the definite and compulsory introduction of the metric system there is not one to which I attach the smallest weight." R. P. W.

English Labor Unions and the Metric System.—That the common people of England are more alive to the advantages of the metric system than are those of the United States is indicated by a letter from the

Secretary of the Lancashire Federation of Trades and Labor Councils, representing 25,000 adult male members. The letter says that these men have from time to time given this question close consideration and arrived at the conclusion that it is desirable in the interests of commerce, as well as of the industrial population, that the use of metric weights and measures shall be made compulsory. Furthermore, that "the trades union interest of the country is not only desirous of seeing the change, but determined to do its utmost to bring it about." R. P. W.

Variety in Fuel Measures.—A New York concern advertises fuel according to the four following measures: *Cauldron,* for coke; *sack,* for charcoal; *ton,* for coal; *cord,* for pine knots. R. P. W.

LABORATORY NOTES—BIOLOGY.

The Clam.—The habit of the clam in burrowing and the use of the siphons may be readily demonstrated by placing live clams in an aquarium jar with the usual water plants, but with three or four inches of earth in the bottom of the jar.

Snails.—Snails are such sluggish animals that the laboratory study of them is liable to be somewhat tedious. If, in addition to distributing a few to each pupil in the usual manner, a rather broad aquarium jar containing fifty to one hundred snails is prepared for reference, the study will be much more satisfactory. Among the very large number of snails there will be sure to be some in any condition desired.

Aquarium.—A narrow rectangular-shaped aquarium is very convenient for many purposes, such as in studying live fishes and crayfishes. A good size is 12 inches long, 10 inches high and 3 inches wide.

A cheap aquarium may be made by using a good wooden box of the desired shape and size as the frame. Cut out the sides and ends, leaving only a framework consisting of the bottom and corners and a narrow strip at the top. Now, cut glass to fit the bottom, sides and ends, and cement in place. Paint the wooden parts and you will have a very serviceable aquarium.

A good cement, used by the U. S. Fish Commission, is made by mixing one part red lead, one part litharge and eight parts of whiting with raw linseed oil to make a *stiff* putty. W. W. Whitney.

IS SILPHIUM PERFOLIATUM A CARNIVOROUS PLANT?

The large cup plant, Silphium perfoliatum, has a square or sharply four-angled stem. The bases of its very large opposite leaves are confluent, forming a cup, capable of holding several ounces of water. These cups usually contain water, even in the midst of a dry season. The cup itself is funnel-shaped and furnishes a convenient receptacle for fungus spores, pollen grains, insects and any other particle of matter which may happen to settle upon the slanting bases of the leaves. Consequently, we

find the water in the base of the cup always containing more or less, usually more rather than less, of organic matter in a state of decay. On the inner surface of the leaves below the surface of the water are numerous five-celled hairs extending into the water in the cup. The terminal segment of the hair seems to differ somewhat from the other segments. The hairs are numerous—twenty-two were counted in one field, which was 38/100 millimeter in diameter. The hairs are about 13/100 millimeter in length, and 3/100 millimeter in thickness. It seems probable that the plant absorbs and uses some of the products from the decaying organic matter found in the cups. As I have been unable to find any reference to this peculiarity of the plant, I desire to make note of it as a promising subject for future investigation. N. A. HARVEY.

Ypsilanti, Michigan.

The North Eastern Ohio Center of the Central Association will hold its next meeting Friday evening and Saturday, Feb. 10 and 11, 1905, at Central High School, University School and East High School, Cleveland.

Further notice will be mailed to members.

NEWS ITEMS.

The Cornell Announcement and Book of Views for the Summer Session of 1905 is at hand. A novel feature of the book of views is the production of two new panoramic views, one of the south and west, and the other of the east and south end of the stone quadrangle. Many will be interested to know that the nature study courses are to be continued under the leadership of Professor Stanley Coulter, of Purdue University. Among the other outside instructors who have accepted calls for the summer are the following: Professor E. P. Baillot (French), of the Northwestern University; Dr. Charles A. McMurry (Geography), the well-known author on Elementary Education; Professor Arthur Tappan Walker (Latin), of the University of Kansas; Professor John A. Walz (German), now at Harvard, but elected at Cornell; Supervisor R. H. Whitbeck (Geography), of the State Normal School, Trenton, N. J.

The library of Cornell University already enjoying an endowment of $300,000, has recently been greatly enriched by a bequest of half a million dollars by the late Professor Willard Fisk, of Florence, Italy. Mr. Fisk was at one time a professor at Cornell, but had lived in Italy for many years. The famous Dante collection formerly given by Professor Fisk to the library at Cornell, now comprises more than seven

thousand volumes. Equally complete collections upon Icelandic literature and upon Petrarch by the terms of the will now come to Cornell. Scholars from other universities in increasing numbers are taking advantage of the rich collections at this university for summer study and research.

The recent ceremony of laying the corner stone of the new Goldwin Smith Hall of Humanities at Cornell was a notable event in the history of the university. The venerable Goldwin Smith, now over eighty years old, delivered a vigorous and inspiring address, which began with these words, half earnest, half jest: "It is perhaps fortunate that the garrulity of age is limited by its feebleness." It may be a matter of interest to teachers to know that the education department of the university will have its rooms in this building.

Report of Meetings.

THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The fourth meeting of the Central Association of Science and Mathematics Teachers was held at the Northwestern University Professional School Building, Chicago, Friday and Saturday, November 25 and 26, 1904.

Friday at 10 A. M., the association was called to order by President Charles H. Smith. Dr. Thomas F. Holgate, Acting President of the Northwestern University, made an address of welcome, after which announcements of committees, etc., were made by President Smith. The following amendments to the constitution was read and adopted:

The annual dues for membership in the Association shall be two (2) dollars per member. Of this the treasurer shall pay to the editor of the official organ not more than one (1) dollar for each member receiving said organ, and to the treasurer of any officially recognized Local Center not more than fifty (50) cents for each member of the Association, also a member of said Local Center, as said Local Center may demand. The remainder is to be used to meet the expenses of the general association. In case there is no official organ, the one dollar which is now paid to School Science shall be held in the treasury to pay for the publication of the proceedings of the association.

The first address was given by Dr. G. B. Frankforter, Professor of Chemistry, University of Minnesota. Subject: "Evolution in Modern Chemistry and its Harmony with Religion."*

A recess of a few minutes was then taken to enable those present to get acquainted, pay dues, etc.

---

* This address will be printed in a succeeding number of School Science and Mathematics.

After the recess Dr. Dugald C. Jackson, Professor of Electrical Engineering, University of Wisconsin, gave an address. Subject: "Desirable Product from the Teacher of Mathematics; The Point of View of an Engineering Teacher."*

The afternoon was devoted to section meetings. At the close of these meetings a trip to the power house of the Commonwealth Electric Co., at 21st Street, was made.

At 6:45 P. M. the members met for dinner at Hull House. Following the dinner, the committee on the "So-called Temperance Physiology and Hygiene Teaching," appointed at the last meeting, made a report, outlining the work done, and recommending that a new committee be appointed to carry on the work. This was followed by an interesting discussion. It was then voted that such a committee be appointed.

The remainder of the evening was devoted to an inspection of the workings of Hull House.

Saturday, November 26, the association was called to order at 9 A. M.

Mr. O. W. Caldwell of the State Normal School, Charleston, Ill., made a statement regarding School Science. He stated that after much urging Messrs. C. H. Smith and C. M. Turton had agreed to take charge of the magazine. President Smith then urged the members to help make the paper a success and outlined the policy of the new editor.

The committee on local centers reported flourishing local centers at Chicago, and Cleveland, O., and that others were being planned. Mr. Crabb of Glenville, O., reported 51 members in the Cleveland centro. On motion the following committee was appointed to carry on this work. Chairman W. E. Tower, Englewood High School, Chicago, Franklin T. Jones, 35 Adelbert St., Cleveland, O., G. P. Knox Yeatman High School, St. Louis, Mo.

The committee on resolutions through its chairman, W. R. Mitchell, Hyde Park (Chicago) High School, made the following report:

That a vote of thanks be given Mr. J. E. Armstrong and the committee on Temperance Legislation; also thanking the Northwestern University for courtesies extended; to the speakers for their excellent addresses; that a vote of thanks be given to the retiring president, Mr. C. H. Smith of the Hyde Park High School, Chicago, as a faithful and earnest President of the Association for the past three years. Adopted.

Thirty new members were elected. The auditing committee reported the treasurer's accounts correct, with a balance in the treasury of $35.57. It also made several recommendations as to the method of keeping the financial records. Report adopted.

A motion was carried that the committee on Temperance Legislation be allowed, on the approval of the executive committee, a sum not to exceed $25 for postage. The committee on Nominations, through its

* This address will be printed in a succeeding number of School Science and Mathematics.

chairman, A. H. Sage of the Oshkosh, Wis., State Normal School, reported the following nominations: President, Otis W. Caldwell, State Normal School, Charleston, Ill.; Secretary, Chas. M. Turton, South Chicago High School; Treasurer, E. Marsh Williams, Lagrange, Ill., High School.

On motion the chair cast the ballot of the association for the above offices. The chair then announced the following committee on Temperance Legislation. Chairman, Mr. J. E. Armstrong, Prin. Englewood (Chicago) High School; H. N. Goddard, Oshkosh, Wis., State Normal School; E. A. Strong, Ypsilanti, Mich., State Normal College; P. Radenhausen, Davenport, Ia.; Miss Rousseau McClellan, Shortridge High School, Indianapolis, Ind.; F. E. Ostrander, Prin. Warren, Ohio, High School.

Adjourned for section meetings.

In the afternoon the works of the Grand Crossing Tack Co. were visited. It was the opinion of all who participated that this was about the most interesting trip ever made by the association.

PHYSICS SECTION CENTRAL ASSOCIATION SCIENCE AND MATHEMATICS TEACHERS.

The Physics Section met Friday, November 25, 2 P. M., in Booth Hall, on Third Floor. The section was called to order by Chairman Tower.

The report of Committee on "Reference Books in Physics," was presented by Mr. A. H. Sage, Chairman, State Normal School, Oshkosh, Wis., who stated that arrangements had been made to send blanks for information to prominent physicists of many states in colleges as well as in secondary schools. On motion the report was accepted and the committee continued. This was followed by an address: "Some Aspects of Technical Education with Especial Reference to the Teaching of Physics," by Dean H. N. Raymond, Armour Institute, Chicago. (Printed elsewhere in this number.)

Mimeograph copies of the report: "A Summary of Suggestions Based on Daily Physics Records," by Dr. E. C. Woodruff, Professor of Electrical Engineering, James Millikin University, Decatur, Ill., were furnished to the section in the absence of Dr. Woodruff, and the following discussion ensued:

Mr. Tower: I should like to call your attention to that portion of the report which refers to covering the subject from one point of view the first half of the year and from another standpoint during the second half; the more familiar subjects in each part of physics to be treated the first semester and the more explanatory topics the second. I should like the opinion of Mr. Raymond on that.

Mr. Raymond: I think it might be an advantage to go over the subject first, touching only on the mountain tops as it were, and then going over again and fill in the details.

Mr. Millikin: I can do no more than touch the high points in my elementary classes. Rather than to add, as has been suggested, such sub-

jects as moment of inertia and angular velocity, I should omit the following subjects: Newton's laws of motion, particularly the second and third, and all mention of impact, and also centrifugal motion. I think in mechanics we should get into the minds of the pupils the idea of how things go, and the chief aim is to get them to think, and to do this you musn't go beyond their depth. As to repeating the subject, our method is to go over the subject the first year, and then a little deeper the next year, and then a little deeper the year following.

Mr. Andrews: I think one test of a good teacher is his ability to judge when he is over the heads of his pupils, and I fear the teacher who does not realize that he is over the heads of his pupils when he introduces the dyne, say, or the law of inverse squares, early in the course, must fall under this test. We may attempt to teach, but nature objects; we may reach the memory but not the reason. Time is an imporant element in the understanding of such subjects, and they should either be returned to later in the course, or be omitted altogether the first year.

Mr. Chas. H. Perrine, Wendell Phillips High School, Chicago, presented two "New Ideas in the Physics Laboratory and Lecture Room," the first a suggestion of introductory work in curve plotting in which curves were drawn to give relation between magnitudes in the English and metric systems; the second, a convenient and flexible Boyles Law apparatus is described on another page.

Informal discussion of several topics followed.

I. Should Physics be changed to the fourth year of the high school course?

Mr. Smith: That would cut off a large number who could not take physics.

Mr. Nichols: It would prevent the possibility of following it with a second year course.

Mr. Spicer. This would interfere with the claims of the other sciences.

Mr. Turton: I am teaching both physics and chemistry, and should much prefer having things as they are so that I can fix the principles of physics in the chemistry course the fourth year.

Mr. Nichols: Do your pupils in chemistry come thoroughly prepared in physics?

Mr. Turton: They have forgotten nearly all they knew but the facts and principles of physics are quickly recalled.

Mr. Raymond: From our point of view, I think we should prefer to have the pupils take physics in the fourth year.

Mr. Milliken: I think the tendency will be to a year or so lower rather than to a year higher.

Mr. Tower: How about having an elementary course the first year, and then towards the end a year of work such as they are then capable of taking up?

Mr. Bishop: I think that is a good suggestion. We introduce the first year an elementary course called physiography.

Mr. Parsons: If it were lowered, how about geometry?

Mr. Spicer: Physiography offers an opportunity to assist us in throwing off a part of the work of the third year, the subject of the barometer for instance.

Mr. Andrews: We have a physiography course in the Chicago high schools the first year; but the physics of physiography is difficult for first year pupils to understand. The barometer, and what it implies, is very difficult for third-year pupils.

Mr. Perrine: Physics may be taken in the Chicago schools either in the third or fourth year; so that the pupils can do as they please.

Mr. Spicer: It seems to me we ought to have an expression of opinion on this matter by the meeting as a whole.

Mr. Turton: I move that it shall stand as the sense of this meeting that it would be undesirable to change physics to the fourth year.

Mr. Laughlin: The fourth year pupils are much better able to handle physics.

The motion being seconded was carried.

II. What will be the effect on physics of laboratory work in Algebra and Geometry?

Mr. Smith: It would take many things out of the way of the physics teacher, and would improve the teaching of algebra and geometry.

Mr. Turton: The trouble is, only about half of the Physics pupils have had geometry.

Mr. Tower: Those taking physics with me have all had geometry.

Mr. Andrews: It is similar with my pupils.

III. What new subject matter should be introduced into physics?

Mr. Smith: I think it would be excellent if we could put in practice some of the theories which we are attempting to put into the minds of our pupils; say subjects referring to public utilities like water works.

Mr. Bishop: I should like to see interference of light waves introduced, and in fact interference of all kinds of waves. Also alternating currents, gas engines, and steam turbines.

Mr. Raymond: As I said before, I should like to see moments of inertia and simple harmonic motion and angular velocity in their simple forms introduced.

Mr. Hawthorne: I think moment of force is desirable.

IV. Is it desirable that the various high schools present the subject of physics in the same order?

Mr. Turton: I think it depends on whether the schools are all in the same school system. In Chicago it would be desirable because pupils frequently change from one school to another, and otherwise are likely to have to repeat or omit some subject.

Mr. Tower: Is there a best order for all the country?

Mr. Milliken: It depends a good deal on local conditions, climatic conditions.

Mr. Raymond: I should have electricity before sound and light.

Mr. Milliken: There is an order which seems to me desirable, the only question is where light, sound and electricity should be placed; because of climatic conditions I have been putting electricity before light. Winter is better for frictional electricity, and light is more conveniently taken up later when the sun is higher.

Mr. Burns: Are we not placing too much emphasis on frictional electricity? May it not be that that is the reason why some pupils think that the dynamo generates its current by the friction of its brushes?

Mr. Andrews: I have classes beginning in February as well as September, and it would be very inconvenient to have a different order for both sets of classes simply because of climatic conditions. Besides I think there is an order indicated by a scientific treatment of the subject which should not be set aside so easily.

Mr. Smith: I have pupils entering in February; but I put them in with the other classes so that they take up the last half of the subject first.

Mr. Andrews: How do they handle such subjects as energy and power?

Mr. Smith: I don't care to discuss that now.

Mr. Tower: I also have pupils entering in February and am forced to put them in the other classes; but I find that although they have rather confused notions of energy and such subjects while studying electricity, yet when they come to these subjects in the fall they grasp them better than the other pupils; so that in the long run they come out fully as well as the others.

Mr. Spicer: I believe there is an unfolding of the theory in physics that is indicated which is more important than anything else; and it certainly seems to me that we should take it in that order.

Mr. Tower: What subject should come after mechanics?

Mr. Andrews: Heat.

Mr. Tower: Let us have a vote on whether heat should follow mechanics.

Mr. Milliken: Rather than following it, I should say, as Mr. Raymond has suggested, that it should be merged into mechanics.

Mr. Bishop: I often have sound following mechanics, and then electricity.

A vote being taken as suggested it was found that all present who voted favored no separation of mechanics and heat.

On motion the section adjourned.

Chas. W. D. Parsons, Secretary.
E. J. Andrews, Assistant Secretary.